WASHBURN & GILLIS ASSOCIATES LTD.

ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR PROPOSED OPEN-PIT MINING PROJECT NEAR UPSALQUITCH LAKE

JANUARY 25, 1990

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Mr. Harry Quint
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Dear Mr. Quint:

Washburn & Gillis Associates Ltd., is pleased to submit the Environmental Impact Assessment Report for the proposed open pit mining project near Upsalquitch Lake. The report has been prepared in accordance with the guidelines issued by the New Brunswick Department of Municipal Affairs and Environment on June 30, 1989.

This report is based on preliminary information contained in the associated document entitled "Draft EIA Report for the Proposed Restigouche Deposit Mining Project" dated August 11, 1989 and prepared by K.D. Phinney, P.Eng. We would also like to recognize the significant technical contributions of Neil D.S. Westoll & Associates Ltd., GEMTEC Ltd., and Mr. R.A. Currie.

.../2

The interactive approach between Washburn & Gillis Associates Ltd., and your team of specialist consultants has ensured that measures required to mitigate environmental concerns have been incorporated in all phases of the project. The report is structured to provide a description of the proposed project and related infrastructure; the environmental setting; to identify environmental concerns associated with the project in the described setting; to identify mitigative measures to address the identified concerns for each of the construction/development, operation, and post-operation phases of the project; and finally to define a monitoring program to ensure compliance with the objectives given in the EIA report and to measure the accuracy of predicted results.

We are available at your convenience to discuss any aspect of this report.

Yours very truly,

Robert Hutt

Robert Hutt, P.Eng.,
Vice-President

RH/cjy

Enclosure

cc: Dr. Neil Westoll

TABLE OF CONTENTS

PAGE

LETTER OF TRANSMITTAL ii

TABLE OF CONTENTS iv

LIST OF TABLES xi

LIST OF FIGURES xiii

1.0 SUMMARY AND PRINCIPAL FINDINGS 1-1

1.1 Summary of Principal Findings 1-5

2.0 INTRODUCTION 2-1

2.1 Marshall Minerals Background 2-1
2.2 Ore Body Location and Description 2-2

2.2.1 Location 2-2
2.2.2 Description 2-2

2.3 Project Rationale 2-4

2.3.1 Economic Feasibility 2-4
2.3.2 Off-Site Milling Arrangements 2-4
2.3.3 Comparative Development Elsewhere 2-8

2.4 Alternative Considerations 2-8

2.4.1 Alternative Mining Methods 2-8

2.4.1.1 Comparative Costs 2-11

2.4.2 Alternative Milling Options 2-11

2.4.2.1 Comparative Costs 2-15

PAGE

2.4.3 Alternative Waste Disposal Methods 2-15

2.4.3.1 Comparative Costs 2-17

2.4.4 Alternative Reclamation Options 2-17

2.4.4.1 Comparative Costs 2-19

2.4.5 Summary 2-20

2.5 Applicable Environmental Regulations 2-21

2.6 Study Methodology 2-21

2.6.1 Approach to the Definition of the Project 2-21
2.6.2 Approach to the Identification of the Valued Ecosystem Components 2-23
2.6.3 Approach to Bounding 2-23

2.6.3.1 Temporal Bounds 2-24
2.6.3.2 Spatial Bounds 2-24

2.6.4 Approach to Information Assemblage and Assessment 2-24

3.0 PROJECT DESCRIPTION 3-1

3.1 Mine Plan 3-3

3.1.1 Development Plan 3-6
3.1.2 On-Site Facilities 3-7

3.2 Waste Management Plan 3-8

3.2.1 Potential for Acid Generation 3-8
3.2.2 Potential Sources of Waste 3-10
3.2.3 Waste Handling and Treatment 3-11

PAGE

3.3 Off-site Facilities 3-22

3.3.1 Diversion of North Branch of Charlotte Brook 3-22
3.3.2 Haulage Road 3-23

3.4 Reclamation Plan 3-23

3.5 Project Costs 3-32

3.5.1 Cost of Development 3-32
3.5.2 Operation and Maintenance Costs 3-33
3.5.3 Reclamation Costs 3-33
3.5.4 Manpower Requirements 3-34

3.5.4.1 Construction 3-34
3.5.4.2 Operation 3-34

4.0 BIOPHYSICAL SETTING 4-1

4.1 Terrestrial Environment 4-1

4.1.1 Description of Mine Site Area 4-1
4.1.2 Description of Haulage Road Area 4-3
4.1.3 Land Uses 4-3

4.1.3.1 Timber Leases 4-3
4.1.3.2 Hunting 4-5
4.1.3.3 Trapping 4-6
4.1.3.4 Campsite Leases 4-7
4.1.3.5 Sugarbush Leases 4-7
4.1.3.6 Ecological Reserves 4-8
4.1.3.7 Fiddlehead Harvesting 4-8
4.1.3.8 Non-Consumptive Recreational Use 4-8
4.1.3.9 Heritage Resources 4-9

4.1.4 Geology and Hydrogeology 4-10

PAGE

4.1.4.1 Surficial Geology 4-10
4.1.4.2 Bedrock Geology 4-14
4.1.4.3 Hydrogeology 4-15

4.2 Aquatic Environment 4-26

4.2.1 Surface Water Resources 4-27

4.2.1.1 Water Quality 4-28
4.2.1.2 Sediment Geochemistry 4-31

4.2.2 Aquatic Habitat 4-32
4.2.3 Aquatic Resources 4-36

4.2.3.1 Fisheries Resources 4-36
4.2.3.2 Benthic Invertebrates 4-41

4.3 Summary of Pertinent Baseline Data 4-42

5.0 ENVIRONMENTAL IMPACT ASSESSMENT - DEVELOPMENT/CONSTRUCTION 5-1

5.1 On-site Facilities 5-1

5.1.1 Proposed Mitigation and Residual Effects on Terrestrial Environment 5-8

5.1.2 Proposed Mitigation and Residual Effects on Aquatic Resources 5-9

5.2 Off-Site Facilities 5-9

5.2.1 Haulage Road 5-9
5.2.2 Charlotte Brook Diversion 5-9

5.2.2.1 Proposed Mitigation and Residual Effects on Aquatic Resources 5-10
5.2.2.2 Habitat Characterization 5-12

PAGE

6.0 ENVIRONMENTAL IMPACT ASSESSMENT - OPERATION 6-1

6.1 Liquid Waste Effluents 6-2

6.1.1 Potential Effects of Acid Mine Drainage on Water Resources and the Aquatic Environment 6-2

6.1.1.1 Proposed Mitigation and Residual Effects 6-6

6.1.2 Potential Effects of Other Liquid Waste Discharges on the Aquatic Resources 6-11

6.1.2.1 Proposed Mitigation and Residual Effects 6-12

6.2 Blasting 6-12

6.2.1 Potential Effects on Aquatic Resources 6-12

6.2.1.1 Proposed Mitigation and Residual Effects on Aquatic Resources 6-15

6.2.2 Potential Effects on Material Adjacent to Pit 6-17

6.2.2.1 Proposed Mitigation and Residual Effects on Material Adjacent to Pit 6-17

6.3 Potential Effects of Stream Diversion on the Groundwater System 6-18

6.3.1 Proposed Mitigation and Residual Effects 6-20

6.4 Ore Trucking 6-20

6.4.1 Transportation Spills 6-21

6.4.1.1 Proposed Mitigation and Residual Effects 6-21

PAGE

6.5 Operation Interruption 6-21

6.5.1 Systems Failure 6-21

6.5.1.1 Proposed Mitigation and Residual Effects on the Terrestrial Environment 6-22

6.5.1.2 Proposed Mitigation and Residual Effects on Aquatic Environment 6-22

6.5.2 Loss of Milling Support 6-23

6.6 Socio-Economic Effects 6-24

6.6.1 Employment Considerations 6-24
6.6.2 Operations and Maintenance Expenditures 6-25
6.6.3 Economic Effects 6-25

6.7 Cumulative Effects 6-27

7.0 ENVIRONMENTAL IMPACT ASSESSMENT - POST OPERATION 7-1

7.1 Reclamation 7-1

7.1.1 Reclamation Measures 7-1

7.1.1.1 Flooding of Sulphides 7-2
7.1.1.2 Exposed Sulphides in Pit Wall 7-4

7.1.2 Proposed Mitigation and Residual Effects 7-7
7.1.3 Proposed Fisheries Management Program 7-11
7.1.4 Proposed Monitoring Program 7-13

7.2 Socio-Economic Effects 7-14

7.2.1 Employment Considerations 7-15
7.2.2 Social Effects 7-16

8.0 PROPOSED MONITORING PROGRAM 8-1

8.1 Introduction 8-1

8.2 Compliance Monitoring 8-1

8.3 Environmental Effects Monitoring 8-2

9.0 REFERENCES 9-1

APPENDICES

Appendix A Micon Report
Appendix B Public Meeting - July 6, 1989
Appendix C Acid Generation Tests
Appendix D Test Pit Logs and Soil Sample Tests
Appendix E Rock Quality Designation Analysis
Appendix F Well Logs
Appendix G Results of Pump Testing
Appendix H Water Quality Data
Appendix I Stream Sediment Geochemical Data
Appendix J Habitat Description

LIST OF TABLES

PAGE

Table 2-1 Alternative Mining Methods 2-10

Table 3-1 Overall Development Plan 3-6

Table 3-2 Estimated Sludge Generation 3-18

Table 3-3 Estimated Quantities of Concentrate 3-18

Table 3-4 Nominal Effluent Flowrates - Operating and After Reclamation 3-21

Table 3-5 Restigouche Project Preliminary Mining Schedule Summary 3-28

Table 3-6 Estimated Manpower Requirements for Operation 3-35

Table 4-1 Summary of Test Pit Data 4-12

Table 4-2 Hydraulic Conductivity Test Results - Overburden 4-14

Table 4-3 Fracture Spacing Data - Selected Boreholes 4-20

Table 4-4 Results of Pump Testing 4-21

Table 4-5 Water Levels in Exploratory Drill Holes - December 9, 1988 and April 20, 1989 4-23

Table 4-6 Water Chemistry - Samples Recovered May 2, 3 and 4, 1989 4-25

Table 4-7 Nominal Flowrates - Charlotte Brook 4-28

Table 4-8 Summary - Surface Water Quality Data Sampling Period September 1988, June, July, August 1989 4-32

Table 4-9 Summary of Electrofishing Results for Sites in the Vicinity of the Restigouche Property, 28-29 June 1989 4-37

PAGE

Table 5-1 Effect of Various Types of Human Related Disturbances on Some Wildlife Species 5-6

Table 6-1 Potential Effects of Spills on Water Quality 6-4

Table 6-2 Potential Effects of Inadequately Treated Discharges on Water Quality 6-4

Table 6-3 Metal Mining Liquid Effluent Regulations 6-8

Table 6-4 Objective Parametre Levels for Treatment Facility Effluent 6-8

Table 6-5 Potential Effects of Residual Metals in Effluent Discharged to Charlotte Brook 6-10

Table 8-1 Proposed Monitoring Program 8-3

LIST OF FIGURES

PAGE

Figure 1-1 Site Location 1-2

Figure 2-1 Location Map 2-6

Figure 3-1 Restigouche Project Location 3-2

Figure 3-2 General Arrangement 3-4

Figure 3-3 Wastewater Production 3-14

Figure 3-4 Flow Diagram - Initial System for Acidic Water Treatment 3-16

Figure 3-5 Flow Diagram - Acidic Water Treatment System 3-19

Figure 3-6 Proposed Haulage Road 3-24

Figure 3-7 Reclamation Plan for Open Pit 3-26

Figure 3-8 Restigouche Deposit 3-30

Figure 4-1 Location of Specific Land Uses and Components of Aquatic Environment 4-4

Figure 4-2 Detailed Site Plan 4-11

Figure 4-3 Interpreted Section 4-16

Figure 4-4 Geological Level Plan 4-18

Figure 4-5 Piezometric Surface 4-24

Figure 4-6 Sample Site Locations 4-29

Figure 5-1 Common Noise Levels and Typical Reactions 5-3

1.0 SUMMARY AND PRINCIPAL FINDINGS

Marshall Minerals Corp. (Marshall), by submission of this Environmental Impact Assessment Report to the New Brunswick Department of Municipal Affairs and Environment (DMAE), is requesting approval for the construction and operation of an open pit base metal mine, located in Northeast New Brunswick (see Figure 1-1). The report has been prepared in accordance with requirements of the Environmental Impact Assessment Regulation of the New Brunswick Clean Environment Act.

This report presents the results of an environmental impact assessment (EIA) which was conducted according to guidelines issued by DMAE under the New Brunswick EIA regulation to assess the environmental concerns associated with the construction and operation of the proposed facility. The purpose of the EIA is to communicate to decision makers pertinent information about the project planning process, the project itself, and the environmental risks and benefits associated with the proposed project. This summary section presents an outline of the major elements of the report including principal findings.

The report is divided into seven additional sections:

Section 2.0 contains the introduction and the approach to the environmental assessment. It provides the rationale for the proposed project, a description of alternatives

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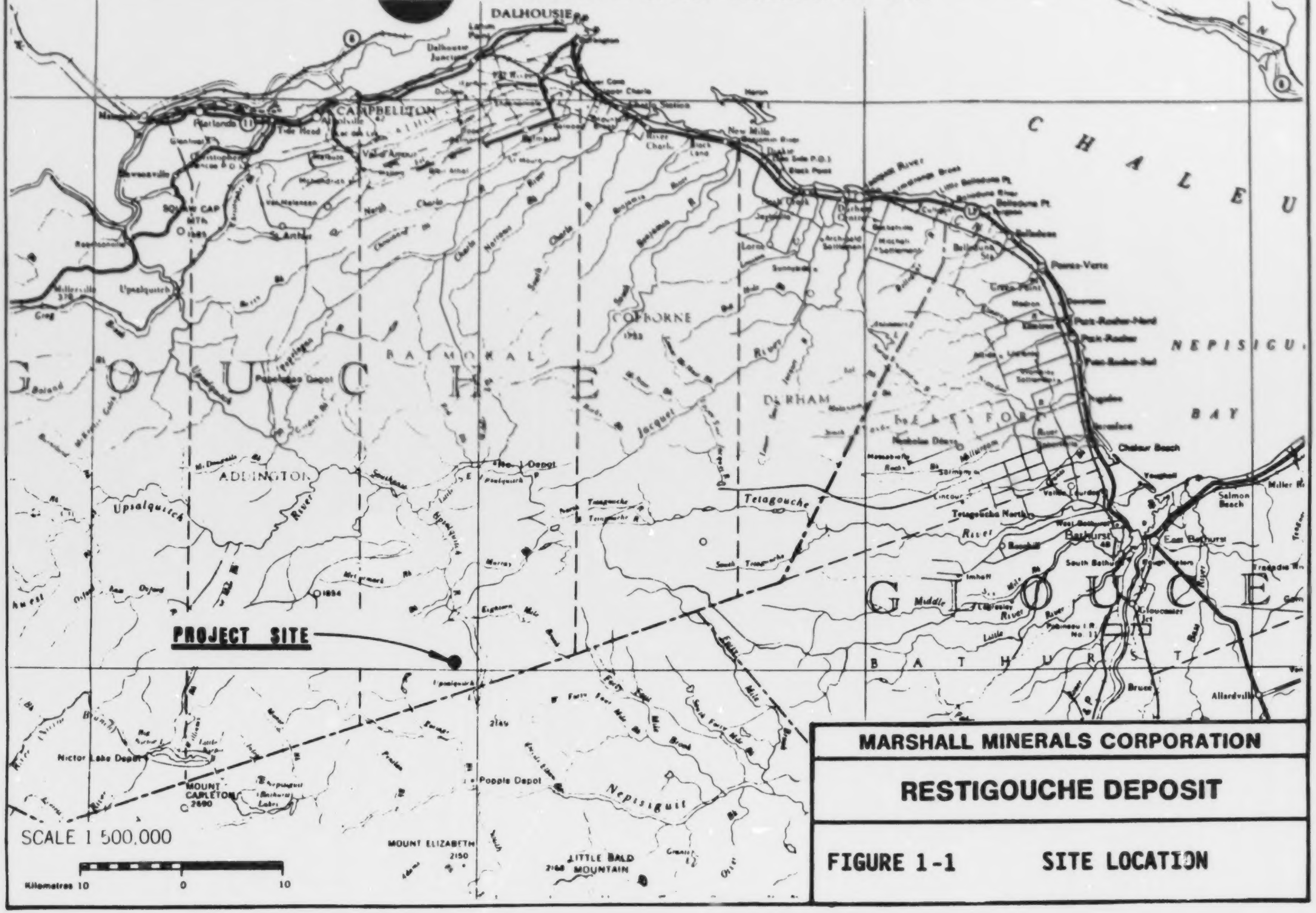

DALHOUSIE
CAMPBELLTON
New Mills
CHALEUR
NEPISIGUIT
BAY
RESTIGOUCHE
GLOUCESTER
BALMORAL
COLBORNE
DURHAM
BERESFORD
ADDINGTON
BATHURST
Bathurst
Chaleur Beach
Salmon Beach
Allardville
Tetagouche
Upsalquitch
Nepisiguit
Popple Depot
Nictor Lake Depot
MOUNT CARLETON 2690
MOUNT ELIZABETH 2150
LITTLE BALD MOUNTAIN 2168
PROJECT SITE
SCALE 1 500,000
Kilometres 10
0
10

MARSHALL MINERALS CORPORATION

RESTIGOUCHE DEPOSIT

FIGURE 1-1 SITE LOCATION

considered for the development of the approach to environmental planning and assessment in the EIA. The approach involved the use of a team of specialists to identify those components of the environment (including the biophysical and socio-economic environment) most at risk from the project. Information was collected on these components to allow identification of the risks and benefits. Close liaison was maintained throughout the project between the team of specialists and Marshall's project group. This close liaison ensured that the project plans incorporated features designed to minimize environmental effects.

Section 3.0 contains the conceptual description of the proposed project and related socio-economic information. The proposed new mine and associated infrastructure is described. This description includes identification of the major components of the project including waste management facilities. Off-site facilities include upgrading the existing access road and diversion of a section of the north branch of Charlotte Brook in the immediate mine area.

Section 4.0 contains information on the biophysical setting. The description includes an outline of the terrestrial and aquatic environment potentially affected by the project. The terrestrial description contains a review of existing groundwater resources, geology, vegetation and wildlife. The aquatic environment description includes a review of the biology of the potentially affected areas (with an emphasis on fish populations) and a description of the hydrology, sediment chemistry and background water quality.

Section 5.0 contains a discussion of the mine development/construction impacts. This section focuses on the impacts associated with the construction of the proposed project. It includes information on potential effects on the terrestrial and aquatic environments and identifies measures required to mitigate environmental concerns.

Section 6.0 contains a discussion of the mine operational impacts. Operation of the facility will result in employment opportunities within the local area, as well as regionally. This section includes information on potential effects on aquatic and terrestrial resources. Mitigative measures required to protect the environment are described.

Section 7.0 contains a discussion of the post-operation (reclamation) impacts. It provides information of the potential environmental impacts during the long-term post-operation phase of the project. Details are provided concerning the proposed reclamation plan.

Section 8.0 contains a description of a program to monitor the construction, operation, and post-operation phases of the proposed facilities. The program describes both monitoring to ensure compliance with existing environmental regulations, and monitoring of potential environmental effects identified during the project.

1.1 Summary of Principal Findings

The environmental impact assessment has been prepared in accordance with the "Guidelines for an Environmental Impact Assessment of an Open Pit Mining Project near Upsalquitch Lake by Marshall Minerals Corporation", issued by the New Brunswick Department of Municipal Affairs and Environment on June 30, 1989.

The principal findings of the EIA include:

1. The Restigouche massive sulphide deposit contains zinc, lead, silver, copper and gold-bearing minerals. The quantity of ore that can be recovered economically by open-pit mining is estimated to be approximately 1 million tonnes. The existence of additional marginal reserves of 600,000 tonnes have been suggested, but the mineralization has not been defined to a level sufficient to permit economic assessment of this material.

2. A portion of the ore body lies underneath both the north and south branches of Charlotte Brook. Recognizing the environmental sensitivity of the Restigouche area, Marshall has decided not to seek permission to mine the ore which lies underneath the south branch. The required diversion of the north branch will incorporate fish habitat improvement measures to replace lost habitat.

3. Consideration of technical, environmental and cost information has determined that open-pit mining is the preferred method for ore extraction.

4. The Restigouche deposit, as presently known, is not of sufficient size to justify the construction of a dedicated flotation mill at the property. Provision has therefore, been made for the ore to be processed either at the nearby East West Minerals Ltd. Caribou Mill or the Heath Steele Mine located north of Newcastle, New Brunswick.

5. Two reclamation alternatives were considered based on either back filling or flooding of the open pit. Technical, environmental, and cost considerations have determined that the preferred method for reclamation of the site includes relocation of the acid generating waste rock and sludge to the open pit, covering the waste with a layer of overburden to reduce oxygen diffusion, flooding of the pit, reclamation of disturbed surface areas, and implementation of a fisheries management plan for the flooded pit.

6. The operation of a mine upon the Restigouche ore body will require the collection and treatment of acidic, metals-bearing drainages. Provision has been made for on-site treatment of these drainages and disposal of the resultant sludge.

7. All facilities related to the storage of acid generating waste rock and sludge and the control and treatment of drainages will be located upgradient of the open pit. Accidental spills or drainages of unacceptable quality will, therefore, flow into the open pit and will not be discharged to Charlotte Brook.

8. The treatment facilities will be designed to protect the water quality of Charlotte Brook under all flow conditions.

9. Surface runoff from disturbed areas will be collected and routed through sedimentation ponds to ensure acceptable levels of suspended solids prior to discharge to Charlotte Brook.

10. Identified environmental concerns associated with the development/construction of the project include:

    - effects on wildlife due to construction noise;
    - suspended solid levels in runoff from disturbed areas; and
    - instream disturbance during construction of the Charlotte Brook diversion.

    Detailed assessment has determined that adequate measures can be taken to mitigate potential environmental effects during the construction phase including:

- construction of permanent and temporary collection and sedimentation ponds prior to the disturbance of construction areas;
- construction of the majority of the diversion facilities in the "dry"; and
- monitor noise levels at selected locations and noise levels associated with specific sources.

11. Identified environmental concerns associated with the operation of the project include:

- water quality of liquid effluents; and
- effects of blasting on aquatic life.

The following mitigative measures will be taken to ensure that there are no residual effects associated with the operation of the proposed mine:

- The treatment facilities will be capable of meeting effluent standards more stringent than the required Metal Mining Liquid Effluent Regulations to ensure that the water quality in Charlotte Brook does not deteriorate to levels that would be detrimental to freshwater aquatic life under all flow conditions. Drainages can be stored in the open pit during extreme low flow periods.

- A field monitoring program will be established to determine safe blasting practices to protect aquatic life.

12. The total direct employment resulting from the Restigouche operation will be 67 people. It is estimated that a total of 268 employees, suppliers and tradespeople will derive direct or indirect economic benefit from the Restigouche mine.

13. The operations and maintenance costs are expected to be between $9.24 million and $13.86 million per year. Most of these expenditures will remain in the local and Provincial economy.

14. Identified environmental concerns associated with the post-operation phase of the project include:

    - effectiveness of reclamation measures; and
    - socio-economic effects associated with the changed land use pattern.

    Analysis and review of similar projects has established that the flooding of the open pit is an environmentally acceptable method for reclaiming the Restigouche site. Measures will be taken to ensure the stabilization of potentially acid generating materials including:

- placement of all sulphide waste rock and sludge in the bottom of the pit and covering it with overburden prior to flooding;
- removal of leachable metals from the sludge, if indicated by leach tests; and
- recontouring and capping of all potentially acid generating rock on the pit walls above the water level.

The permanent loss of the existing forest cover in the open pit area is expected to be more than compensated for by the additional trout habitat and the establishment of a recreational fishery for trout in the flooded pit.

15. A detailed monitoring program has been developed for the construction/development, operation and post-operation phases of the project. The monitoring program will be used to ensure compliance with the objectives given in the EIA Report and to measure the accuracy of the predicted results. Monitoring will identify concerns and will be used to ensure an environmentally compatible project.

2.0 INTRODUCTION

2.1 Marshall Minerals Background

Marshall Minerals Corp. (Marshall) is an international mineral resource company engaged in the exploration and development to production of mineral properties. Canadian-based and publicly traded, it has been managed by its current Chairman and Chief Executive Officer, Mr. Harry G. Quint, for the last eight years. According to Marshall's Information Circular dated August 8, 1989, Mr. Quint and his family own approximately 24 percent of the company directly and through Gail Resources Inc.

Marshall has established strong financial links with North American and European investors and has assembled a team of highly qualified and experienced senior professionals to bring its various properties to the production stage.

The Restigouche property was acquired by Marshall in March 1988 from Placer Dome Inc. (PDI) and Calgroup Graphics Corporation Ltd. (Calgroup), by purchasing the PDI working interest for cash and the Calgroup royalty interest for a combination of cash and stock. Marshall now holds a 100% interest in the Restigouche lead-zinc-silver deposit located on this property.

For the work performed on the Restigouche property, to date, Marshall has raised and expended flow-through funds. It has also raised substantial equity capital in Switzerland through a convertible issue. Additional project financing will be arranged upon approval of the required EIA.

2.2 Ore Body Location and Description

2.2.1 Location

The Restigouche mineral deposit is located approximately 70 km west of Bathurst within the headwaters of the Upsalquitch River, as shown in Figure 1-1. Access to the site, which is located near the headwaters of Charlotte Brook, is provided by Highway 180.

2.2.2 Description

The Restigouche massive sulphide deposit contains minerals bearing zinc, lead, silver, copper and gold. The deposit has a length of approximately 425 m, width of approximately 120 m, and a thickness of less than 50 m. The deposit is exposed south of Charlotte Brook (dips west at between 30° and 50°) and plunges at approximately 25° in a northerly direction. The quantity of ore that can be recovered economically by open-pit mining is estimated to be approximately 1 million tonnes. This "proven geological reserve" contains approximately 0.33 wt% copper, 7.76 wt% zinc, 6.06 wt% lead, 127 g/t silver and 1.2 g/t gold.

The economic minerals are contained predominantly within a massive sulphide matrix. The sulphides, in order of predominance, include: pyrite (60 wt%), sphalerite (20 wt%) and galena (10 wt%). The zone also contains chalcopyrite (<1 wt%), arsenopyrite (<1 wt%) and traces of other iron sulphides, copper-iron sulphides and copper-arsenic sulphides. The remainder of the zone consists of siliceous gangue.

Marshall commissioned multi-element semi-quantitative spectrographic analysis on the two composites prepared from drill core samples for metallurgical testing at Lakefield Research of Canada Ltd. (Lakefield Research). The concentrates produced from testing of these composites were also assayed for, among other elements, arsenic and mercury. Based on these data, the arsenic content of Restigouche ore falls in the range 0.2-0.5 wt% and the mercury content was consistently less than 0.005 wt%.

The rock below the ore zone is characterized by the presence of disseminated sulphides. The average sulphide content of this "stringer zone" ranges from 5 to 10 wt%. Pyrite is the main sulphide. The rock above the ore zone contains less than 1 wt% sulphides and consists primarily of felsic volcanics. The acid generating potentials of these various zones are considered in Section 3.2.1. No major faults are known to traverse the ore zone.

Access to the ore body will require diversion of the north branch of Charlotte Brook. Recognizing the environmental sensitivity of the Restigouche area, Marshall has decided not to mine the ore which lies directly underneath the south branch of Charlotte brook. To extract this ore would require the construction of a major new southerly diversion of both branches of the brook. By making this election, Marshall is leaving unmined some 80,000 tonnes of ore with a net smelter return value in excess of $5 million. Marshall has also considered leaving the north branch of the brook undisturbed but this would result in rendering approximately one-third of the ore body unextractable. The project then becomes economically unattractive to Marshall.

2.3 Project Rationale

2.3.1 Economic Feasibility

The "proven geological reserve", referred to in Section 2.2, corresponds to a gross economic value of approximately $250 million, based on July 1989 metal prices. The ongoing economic feasibility study, which will be submitted to the New Brunswick Department of Natural Resources and Energy (DNRE) in accordance with the Mining Act, indicates that at these prices a net revenue of $30 million may be realized by Marshall after all expenses for mining and processing the ore are accounted for. As part of the feasibility study, sensitivity analyses will be performed using various metal prices.

2.3.2 Off-Site Milling Arrangements

The Restigouche deposit, as it is presently known, is not of sufficient size to justify the construction of a dedicated flotation mill at the property. Marshall, therefore, proposes to mine the ore from Restigouche and transport it to an existing mill in the area.

There are two mills in northeastern New Brunswick which could accept Restigouche ore, the relatively new mill at the Caribou deposit of East West Minerals Ltd. (East West) and the refurbished mill at the Heath Steele property of Noranda and Brunswick Mining and Smelting (Heath Steele). Although both mills have expressed interest in receiving Restigouche ore, Caribou is the closer of the two (35 km versus 75 km; Figure 2-1) and would be the less costly option for Marshall from the ore transport aspect.

The two mills have different attractions to Marshall. The 2000 tonnes per day flotation mill at Caribou has been completed recently and is, therefore, essentially a new mill. It is designed to produce a bulk Pb-Zn concentrate from the Caribou ore and East West has sales contracts with existing smelters in Europe for this concentrate. The mill was started up in late 1988 but has not yet reached design recovery on the Caribou ore. The Heath Steele mill, on the other hand, is a fairly old 4000 tons (3,600 tonnes) per day mill which has been partly refurbished to treat Stratmat, B-Zone and E-Zone ore from the Heath Steele property at a rate of approximately 1800 tonnes per day. There is spare grinding and flotation capacity in the existing mill building and Heath Steele has indicated that this capacity could be made available for treatment of third party ore.

Marshall has examined both mills and their metallurgical circuits and has commissioned extensive bench scale testwork at Lakefield Research (near Peterborough, Ontario) on the Restigouche ore. Initial results have indicated that the mill circuit at

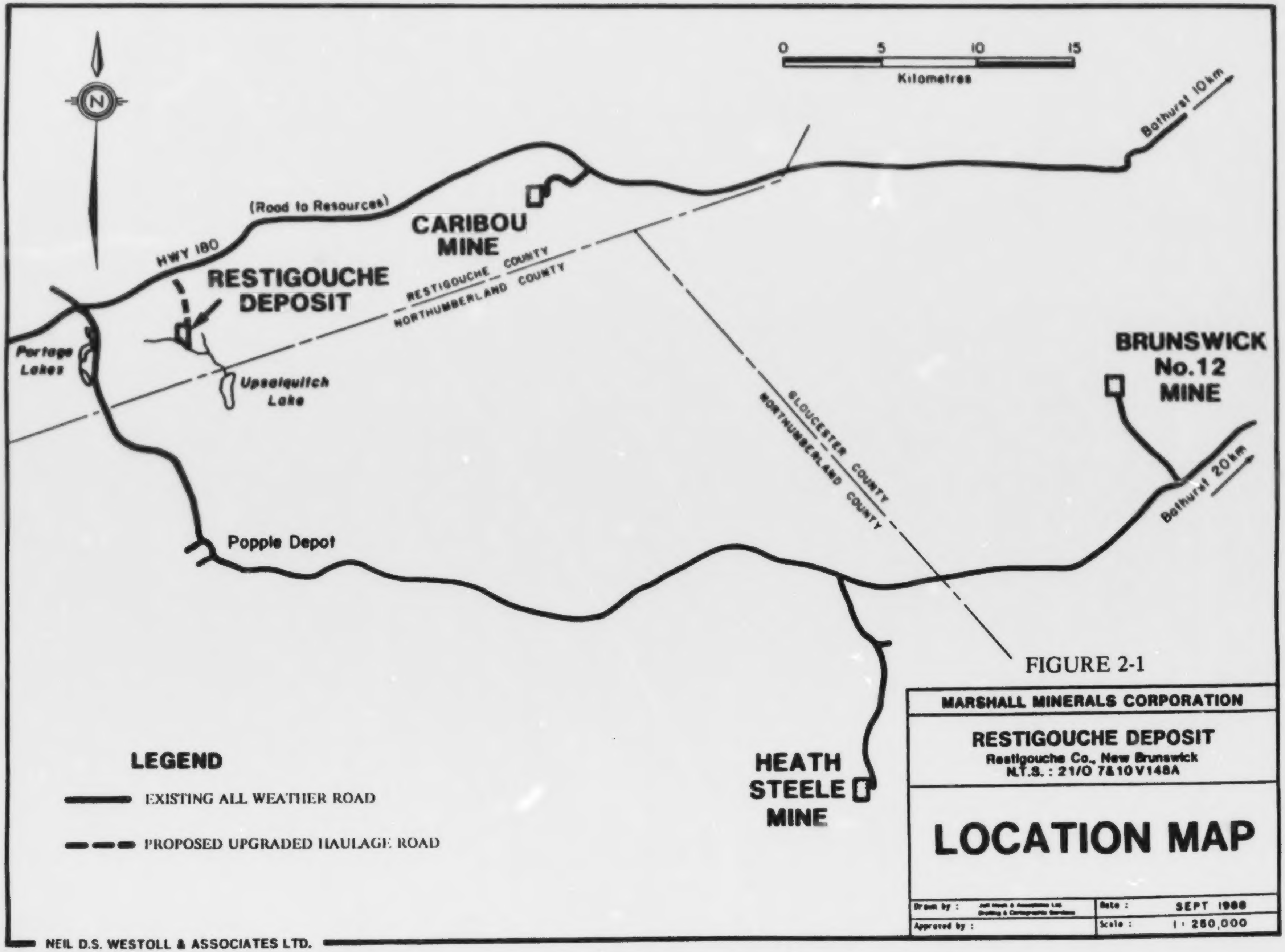

0
5
10
15
Kilometres
Bothurst 10km
(Road to Resources)
HWY 180
CARIBOU MINE
RESTIGOUCHE DEPOSIT
RESTIGOUCHE COUNTY
NORTHUMBERLAND COUNTY
Portage Lakes
Upsalquitch Lake
GLOUCESTER COUNTY
NORTHUMBERLAND COUNTY
BRUNSWICK No.12 MINE
Bothurst 20km
Popple Depot
HEATH STEELE MINE
LEGEND
EXISTING ALL WEATHER ROAD
PROPOSED UPGRADED HAULAGE ROAD
MARSHALL MINERALS CORPORATION
RESTIGOUCHE DEPOSIT
Restigouche Co., New Brunswick
N.T.S. : 21/O 7&10 V148A
LOCATION MAP
Drawn by :
Approved by :
Date : SEPT 1988
Scale : 1 : 250,000
NEIL D.S. WESTOLL & ASSOCIATES LTD.

FIGURE 2-1

Caribou and the B-Zone circuit at Heath Steele will match the Restigouche ore very well, but that capital additions would be necessary at the Heath Steele mill to enable the Restigouche ore to be treated there.

Accordingly, negotiations with East West were initiated in early 1989 by Marshall, and "Heads of Agreement" between the two companies were signed on July 4, 1989. Under this agreement, pending satisfactory results from a bulk sample test, Marshall will deliver ore to the Caribou mill at an annual rate of between 240,000 and 360,000 tonnes and Caribou will produce a bulk concentrate, meeting the specifications of its existing smelter contracts in Europe, from that ore and sell it to the smelters.

The Marshall-East West agreement specifies certain metal recovery figures that the Caribou mill must achieve, and envisages that the net smelter return from sale of the resulting concentrates will be split 65% Marshall:35% East West. In order for East West to be prepared to guarantee the metal recoveries specified in the agreement it will be necessary for Marshall to provide a bulk sample of the Restigouche ore for a plant trial at the Caribou mill.

In the event that the Caribou plant trial does not produce results satisfactory to both Marshall and East West, Marshall retains the option of withdrawing from the agreement and designing its own dedicated circuit in the Heath Steele mill for treatment of Restigouche ore. While the plant trial results will, therefore, be of critical importance to the choice of mill, Marshall is satisfied that sufficient milling capacity is available in the local area to treat the Restigouche ore.

2.3.3 Comparative Developments Elsewhere

Comparative developments in New Brunswick, recently to have been approved by the regulatory agencies, include the proposed Stratabound project on the Portage River and the several satellite mining projects currently being developed by Noranda near the Heath Steele Mines area. These projects will involve the operation of open-pit mines, the collection and treatment of acidic waters, and reclamation by a variety of techniques including flooding, backfilling, and various "capping" measures to seal sources of acid generation.

2.4 Alternative Considerations

2.4.1 Alternative Mining Methods

The Restigouche deposit outcrops at its southern end and plunges north at approximately 25°. It is, therefore, ideally suited for extraction by open-pit mining methods, and the selectivity afforded by such methods would ensure maximum recovery of the ore. Nevertheless, Marshall commissioned Micon International Ltd. (Micon) to perform an "Analysis of the Cost of Mining the Restigouche Deposit by Underground or Open-Pit Methods", in order to assess which mining method might be expected to yield the greater overall economic benefit when all costs including those associated with mitigation of potential environmental effects are considered. The Micon Report (dated January 12, 1990), is included as Appendix A to this report.

In summary, the Micon report indicates that the open-pit method is the clear economic choice for mining the Restigouche deposit. Not only will open-pit methods recover a greater proportion of the in-situ ore than would the underground methods evaluated, but the direct operating cost differential between the two methods would render it more economic to mine by open-pit until the waste to ore ratio exceeds about 13 tonnes of waste per tonne of ore. These differences were sufficient for Micon to conclude that "future planning of production from the drill-proven reserve at the Restigouche property should be restricted to mining by open-pit methods". Marshall is currently in the process of detailed mine design, involving open-pit mining methods for the presently defined reserves. Preliminary estimates are that the reserves would be mined at an overall strip ratio of just over 6 tonnes of waste per tonne of ore.

The two alternative mining methods would exhibit different surface expressions and would show different environmental risk profiles. These differences are outlined in Table 2-1.

TABLE 2-1

Alternative Mining Methods

Item	Project Features Open-Pit	 Underground
Description	- open pit - large waste rock storage area - sulphide rock storage area - diversion of north branch Charlotte Brook	- decline - small waste rock storage area - smaller sulphide rock storage area - diversion of north branch Charlotte Brook - quarry for fill material
Contaminated Drainages	- pit minewater - waste rock runoff (solids only) - sulphide rock runoff	- minewater - minor waste rock runoff (solids only) - sulphide rock runoff
Emergency Holding Pond	- storm ponds; pit as back-up	- storm ponds
Reclamation Plan	- transfer sulphide rock into pit - flood pit - recontour/vegetate waste rock storage area - recontour/clean-up site	- transfer sulphide rock into mine - flood mine - bulkhead decline - recontour/clean-up site - reclaim waste rock pile
Environmental Risks		
- Operating Phase	- overflow of acidic drainages into brook; remote due to additional holding capacity provided by pit	- overflow of acidic drainages into brook; mine cannot be allowed to flood due to "fixed" underground facilities
- After Reclamation	- overflows from flooded pit	- seepages from underground into brook

2.4.1.1 Comparative Costs

In the operating phase there will be little to no difference in the capital costs for drainage control facilities and treatment systems. Mine operating costs have been estimated to be $27/tonne and $41/tonne for open-pit and underground methods, respectively (see Appendix A). These costs include a nominal allowance for environmental measures. Due to the larger volume of potentially acidic drainages from the open-pit wastes compared to those resulting from underground mine wastes, the open-pit treatment system would have slightly higher associated costs.

Reclamation of an open-pit operation would be more expensive than reclamation of an underground mine. There would be more potentially acid generating waste to return to the mine and recontouring/vegetating of a much larger inert waste rock pile for open-pit as compared to the underground operation. The costs of the two alternatives have been estimated by Marshall at $1.6 million (open-pit) and $500,000 (underground).

2.4.2 Alternative Milling Options

There are two operating mills in northern New Brunswick which have the facilities to process ore from the Restigouche deposit. These include the mill at Heath Steele Mines and the East West Minerals Ltd. mill at the Caribou deposit (see Section 2.3.2). Marshall has held discussions with the owners of both the Caribou and Heath Steele mills to confirm that each operation is capable of receiving, storing and processing

Restigouche ore and of disposing of tailings and effluent derived from the ore in approved facilities with sufficient capacity. Marshall will cooperate with the mill chosen to process the Restigouche ore with respect to the generation of new waste management plans, should these be required for approval to be given for the processing of its ore at that mill.

Heath Steele (Arsenault, Heath Steele Mines, personal communication, 1989) and Caribou (C. Smith, East West Minerals Ltd., personal communication, 1989) have each indicated that they have the capacity to treat Restigouche ore, that when received the ore would be stored on an approved stockpile (the drainage from which is controlled and treated), that the ore would be treated using conventional milling processes and procedures very similar to those with which it treats its own ore and that the waste products derived from the Restigouche ore (tailings and effluent) would be disposed of in an approved tailings pond, which would have sufficient capacity for them, in accordance with current practices. It should be noted that the Caribou operation has specifically encouraged the development of off-site ore deposits as feed for its mill.

The milling facility which processes the Restigouche ore will have all of the necessary approvals from the regulatory agencies for the processing of massive sulphide ores to produce lead, zinc and copper concentrates. The Restigouche ore is of similar composition to the ores which are already processed at these mills. Laboratory scale milling tests have confirmed that similar process conditions and reagents would be required to recover the economic minerals from the Restigouche ore.

Ore would be hauled to the selected mill, stored on a pad with controlled drainage, and then passed through the milling circuit. If necessary, the existing ore storage pads would be expanded to enable storage of additional ore from Restigouche.

The quantities and composition of wastes from the processing of Restigouche ore would be very similar to those for the processing of an equivalent quantity of ore from the Heath Steele or Caribou deposits. The wastes consist of "tailings" which would be discharged into existing approved disposal areas (tailings ponds). The tailings would consist of finely ground "rock", (i.e. that portion of the ore which remains after removal of the majority of the economic minerals, and process water).

The "rock" portion would consist primarily of iron sulphides and would have a similar potential for acid generation as the residual solids that have been or that are currently disposed of at the Heath Steele and Caribou sites. The liquid portion of the tailings would consist of alkaline water containing calcium sulphate and flotation reagent residuals. It is known that excessive thiosalts in mill effluent can lead to the generation of acidic conditions within receiving streams. Marshall therefore commissioned assays for thiosalts on the rougher tail solution from one of the last flowsheet tests performed for Marshall at Lakefield Research (Test RC 1-26), and they yielded the following values:

S_2O_3 - 101 mg/L

S_4O_6 - 14.3 mg/L

Based on these assays, the liquid portion derived from the milling of Restigouche ore would contain substantially less thiosalts than the processing effluents which have been produced at the Caribou and Heath Steele mills. The Restigouche ore is expected to generate less than 1 t/d of thiosalts at an ore milling rate of 2000 t/d. The Caribou mill produces approximately 3 t/d of thiosalts at this milling rate. Measurements obtained during the previous operations of Heath Steele mill indicate the generation of approximately 3 to 4 t/d (Rolia and Tan, 1985). Although only one sample was analyzed by Lakefield Research, Marshall believes the results to be valid; thiosalts are derived predominantly from pyrrhotite, which is known to be very rare at Restigouche.

Microscopic examination of diamond drill core samples of Restigouche ore has been undertaken by several groups (Teck in 1966, Placer in 1975 and Marshall in 1988). The results of all these examinations are similar; pyrrhotite is noted as occurring in "trace amounts" (Lakefield, 1966) or "minor amounts" (Lakefield, 1988) in the ore, but the Placer report noted that "no pyrrhotite can be detected in any of the samples submitted for study" (Ball, 1975). In contrast, the contents of pyrrhotite at Heath Steele range between the separated deposits from less than 1% (Stratmat) to approximately 20% (copper-rich base of B-Zone), based upon informal discussions with Heath Steele personnel. The current mill feed at Heath Steele, which is a mixture of Stratmat and B-Zone ore, is estimated to average between 2 and 5% pyrrhotite.

2.4.2.1 Comparative Costs

No extraordinary costs associated with mitigations of environmental concerns have been identified for the available milling alternatives. Milling of the Restigouche ore at the Heath Steele mill site would be somewhat more expensive than for milling at the Caribou site due to increased transportation costs. However, both sites remain viable with respect to the economics of the proposed mine development.

2.4.3 Alternative Waste Disposal Methods

The operation of a mine upon the Restigouche ore body would necessitate the collection and treatment of acidic, metals-bearing drainages. These drainages would be produced by the contact of precipitation and groundwater with the products of sulphide oxidation. Sulphides in the ore and waste rock would produce acid and soluble metals when exposed to the atmosphere. The acid and soluble metals would dissolve into water which contacts the exposed sulphides. Such water would contain the sulphates of iron, zinc, lead, copper and possibly other metallic elements.

The release of this water into the environment without prior treatment would be detrimental to terrestrial vegetation and aquatic life. Treatment of these drainages would therefore be required to meet existing regulatory requirements and to ensure that the treated effluent would be non-toxic when discharged into the environment.

A method that is commonly used for the treatment of acidic mine drainage is the addition of an alkaline reagent to neutralize the free acidity and precipitation of the metallic elements as insoluble hydroxides. This method is used because of its ease of application, effectiveness in producing an acceptable water quality, and economic viability.

The major disadvantage of the method is the production of a metals-rich sludge which must be disposed of in a well-controlled manner. In some instances, such sludges can be dewatered and shipped to a metals refining plant for recovery of the economic metals (such as copper and zinc) and the production of a stable iron-rich solid residue. However, the costs of dewatering and transport to refining plants, and the complications that such sludges can cause to refining processes, has limited the interest in and availability of this option (MacDonald et al, 1989). Alternatives considered for the Restigouche operation included a pressure filtration system to dewater the sludge for its storage and eventual disposal on-site or its shipment to an approved off-site disposal location.

Various alternatives are available for the disposal of the metals-rich hydroxide sludge. The sludge could be transported to the ore processing mill for disposal with the tailings, a normal practice in the base metal mining industry. If this is not acceptable, due to regulatory policy, the sludge can be disposed of at the Restigouche site. Since no specific agreement has been reached and approved, provision has been made for on-site sludge disposal.

2.4.3.1 Comparative Costs

The following estimated costs for the treatment alternatives at the Restigouche site are based on a mean annual flowrate of 41 m^3/h and total acidity of 1500 mg/l (as $CaCO_3$):

	Capital ($ millions)	Annual Operating ($ millions)
Lime neutralization/off-site sludge disposal	0.7	0.20
Lime neutralization/sludge dewatering/ on-site sludge disposal	1.9	0.28
Neutralization/metals recovery/sludge dewatering/ on-site sludge disposal	2.1	0.32

The quality and quantity of the wastewater requiring treatment depends on several site-specific conditions including the amount of acid-generating sulphide rock that is exposed and the details of collection and diversion facilities. Provision has, therefore, been made for staged development of the treatment facilities with allowances for lime neutralization, sludge dewatering and on-site sludge disposal (see Section 3.2.3).

2.4.4 Alternative Reclamation Options

All minesites require reclamation measures prior to their abandonment. Such measures are required to ensure that the area:

- poses no safety risks with respect to humans and wildlife;
- is stable with respect to the potential for acid generation;
- becomes productive biologically or otherwise, and
- is aesthetically acceptable.

Various measures, prescribed by regulations under the Province's Mining Act or otherwise considered as normal industrial practice, are used to ensure that a site poses no safety risks. Such measures include the removal of all buildings and other minesite facilities. All such measures will be completed at the Restigouche site to the satisfaction of the regulatory authorities.

The stabilization of the site to ensure that acid generation will not pose a long-term risk to the environment is the most critical factor associated with reclamation. Lack of success in stabilization would necessitate the perpetual operation of a system for the collection and treatment of residual acidic drainages, such as seepages from the mine and from sulphide waste rock dumps. Experience throughout Canada and elsewhere clearly indicates that the prevention of acid generation can only be achieved, on a permanent basis, if the exposure of sulphides to atmospheric oxygen is severely limited (Environment Canada, 1987). To this end, all reclamation methods are based on covering sulphide materials with "caps" having very low permeability to inhibit the rate of transfer of oxygen from the atmosphere to the sulphides. Methods involving the covering of exposed sulphides by earthen materials and vegetating the covered area to limit the access of both air and water have achieved mixed results. This is due, at least in part, to the relative ease with which air can permeate earthen materials. The preferred method involves the flooding of sulphide materials with water. Water has proven to be the most effective and practical barrier for preventing atmospheric oxygen from contacting acid generating materials.

The restoration of biological production at the Restigouche site will also be a primary objective of reclamation. Restoration of production will be accomplished by ensuring that vegetation can re-establish within the disturbed area. Thus, disturbed areas will be sloped as necessary to ensure physical stability, covered with topsoil, if necessary, and vegetated. Completely vegetating the open-pit mine would necessitate backfilling of the pit. Although the permanently flooded pit alternative will displace terrestrial habitat and vegetation, provision will be made for fisheries development to provide additional fish habitat for the area.

2.4.4.1 Comparative Costs

Estimated costs for the reclamation of the open-pit development at the Restigouche site are as follows:

	$ millions
Relocate acid generating waste rock and sludge to open pit, cover waste rock, flood pit, reclaim disturbed areas including inert waste rock pile, implement fisheries management plan	1.6
Relocate acid generating waste rock, sludge, inert waste rock to open pit, backfill pit, contour and vegetate disturbed areas	12.5

The costs for the flooded pit assume the return of one million tonnes of potentially acid generating waste rock to the pit at a cost of $2.00/tonne (see Appendix A), covering of this waste with suitable material prior to flooding of the pit, contouring of the inert waste dumps and re-vegetation of these dumps and the disturbed area. The costs for the backfilled pit assume the return of six million tonnes of waste to the pit to re-establish pre-construction contours at a cost of $2.00/tonne and a re-vegetation program similar to the flooded pit alternative.

The preferred alternative for reclamation of the Restigouche site involves the use of flooding to ensure the prevention of future acid generation. Thus, all acid generating waste rock will be re-located to the open pit for reclamation to ensure its permanent stability. The pit will then be allowed to flood. Flooding will ensure that exposed sulphides in the walls of the mine are also covered with water. The degree of success of the proposed reclamation plan will depend on the extent to which all sulphides are permanently flooded. Any acid generating sulphides located in the walls of the mine, above the flooded level, will be adequately sealed with a material of very low permeability.

2.4.5 Summary

Several mining, milling, waste disposal and reclamation alternatives have been considered to allow the environmentally acceptable and cost effective development of the Restigouche ore body. The proposed development consists of an open-pit mine, off-site milling, on-site treatment and waste disposal, and reclamation based on flooding of the open pit.

2.5 Applicable Environmental Regulations

The project will meet environmental requirements specified by the Provincial and Federal governments. The Province, in consultation with the Federal government, issues approvals to "construct" and "operate" under the Clean Environment Act. These approvals specify conditions with which the development must comply throughout the construction, operation and reclamation phases. These conditions will include specific effluent water quality requirements. In this regard, other new base metal mining projects in New Brunswick have been required to meet the water quality regulations specified in the "Metal Mining Liquid Effluent Regulations and Guidelines" (Environment Canada, 1977). Under the New Brunswick Mining Act, the Province will require Marshall to deposit a security or bond for both reclamation and rehabilitation of the mine site following abandonment. The amounts are established by the Province based upon the areal extent of disturbed land and the environmental risk involved with the project.

2.6 Study Methodology

2.6.1 Approach to the Definition of the Project

The review of environmental effects associated with the proposed mining operations at the Restigouche property was conducted by a diverse team of specialists representing various disciplines. This team was composed of specialists in waste management, groundwater assessment, and fisheries and environmental management. In the definition of the project, the team of specialists worked closely with the design group from Marshall. Throughout the course of project definition, several options for various components of the project were reviewed to determine their environmental and economic implications. The project description, which has been outlined in Section 3.0, includes recommendations derived from this interactive process. This process made extensive use of the existing environmental regulations for the province of New Brunswick and Environment Canada and additional guidelines such as those developed for conducting of the Restigouche property EIA.

The technique employed in the review was modified as suggested by Beanlands and Duinker (1983) in the report titled "Ecological Framework for Environmental Impact Assessment in Canada". This approach emphasizes the use of "Valued Ecosystem Components" as the focal points for impact assessment. Valued Ecosystem Components (VECs) are defined as those aspects of the ecosystem or associated socio-economic system which are important to humans. The components could include for example: (1) components important to humans commercially; (2) components which may be important socially; (3) components which may be essential to the food web; or (4) components which may be reliable indicators of environmental change.

Another critical element of the impact assessment procedure involves bounding of a project or identification of spatial and temporal bounds. Both the approach to the identification of the VECs and the approach to bounding for the project components are described in the sections which follow.

2.6.2 Approach to the Identification of the Valued Ecosystem Components

Two approaches were taken to identify the VECs. First, those parameters for which Provincial or Federal regulations are in place were identified. An example of the identified parameters include regulations for levels of contaminants in wastewater.

The second approach used for the identification of VECs involved a scoping exercise based on experience gained during other comparable impact assessments elsewhere in New Brunswick and Canada, supplemented by available information on the environment surrounding the Restigouche site. Biophysical factors considered included populations of aquatic and terrestrial organisms which may be affected by the operation of the facility.

2.6.3 Approach to Bounding

The concept of bounding is not new for the environmental impact assessment of projects. The traditional approach involved assessing changes to the environment within the physical boundaries of development. Beanlands and Duinker (1983) determined that in order to properly evaluate impact assessments, physical and biological properties must be determined temporally and spatially. This approach has been taken for the determination of bounds for the proposed development at the Restigouche site.

2.6.3.1 Temporal Bounds

The temporal bounds for the project can be roughly categorized in three components: development/construction, operation and reclamation. Development/construction of the open-pit operation will occur over approximately a 6 month period. The mine is expected to operate for approximately 4 years. In contrast, the reclamation of the mine site will be for the long-term and will be designed to ensure that the mine is not a source of future environmental degradation.

2.6.3.2 Spatial Bounds

Spatial bounds for the socio-economic aspects focused on the economic activity generated by the project, together with an assessment of the services and facilities available within the immediate area. The spatial bounds selected for the bio-physical assessment are essentially the immediate environs of the proposed activities, the mine itself and the adjacent water courses. These immediate bounds were also used for assessment of visual and noise effects.

2.6.4 Approach to Information Assemblage and Assessment

Information on the project definition for the proposed construction and operation has been provided by Marshall. The interactive approach used during definition of the project resulted in some elements of the project conceptual design being modified to conform better to existing regulations and constraints. In addition to the physical description of the project, socio-economic information obtained from Marshall included projected labour force requirements, identification of skills required, information on construction scheduling, capital costs, operating costs and operating philosophy.

Categorization of the existing environment for the proposed project was facilitated through discussions with resource managers and administrators who are responsible for natural resources within the area identified by the spatial bounds. In certain situations, specific background information was not available at the required level of detail and field work was conducted to address data deficiencies.

To assist in the assemblage and assessment of information, public consultation was also undertaken. Interests and concerns were expressed at a public information meeting and were incorporated into the study approach. The public meeting, held in Campbellton on July 6, 1989, is described in Appendix B.

Guidelines issued by DMAE required that a context for impact significance be established. The goal was to provide a clear indication of action levels for those parameters to be monitored. The guidelines further suggest that the criteria for impact significance be objective. Regulated or recommended allowance levels for deviation from the background environment were used as a basis against which to measure significance. For instance, any drainage streams with potential to exceed regulated values were judged to have significant impact and appropriate mitigation measures were included in the project description.

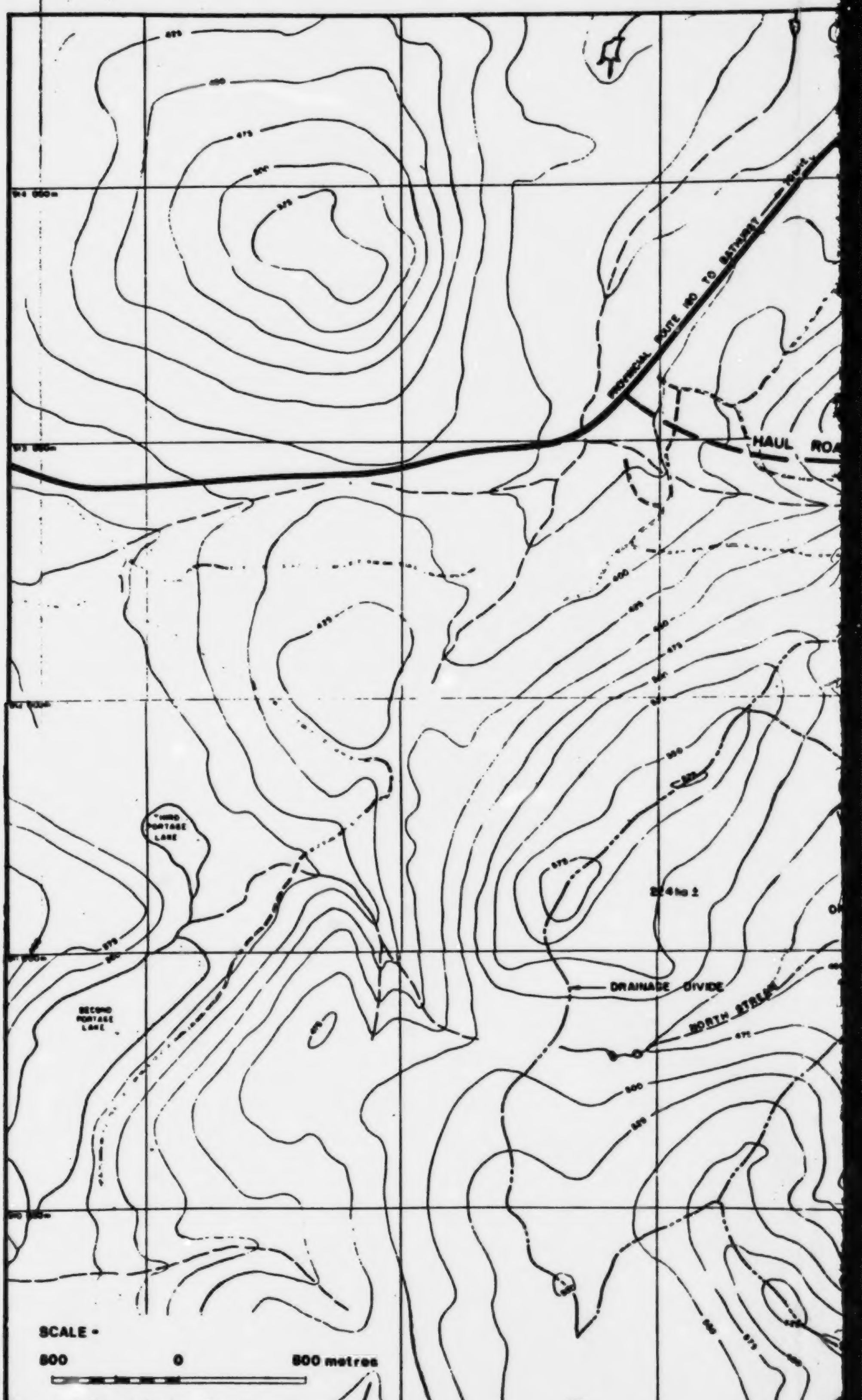
Any deviation from the background was also judged to be significant where it was predicted that the changes would cause a significant change in a process or state within the bounded area, resulting in a sustained depression of fitness or density below the naturally occurring levels. Where such changes were predicted, mitigation was recommended and monitoring programs for the effectiveness of mitigation have been designed.

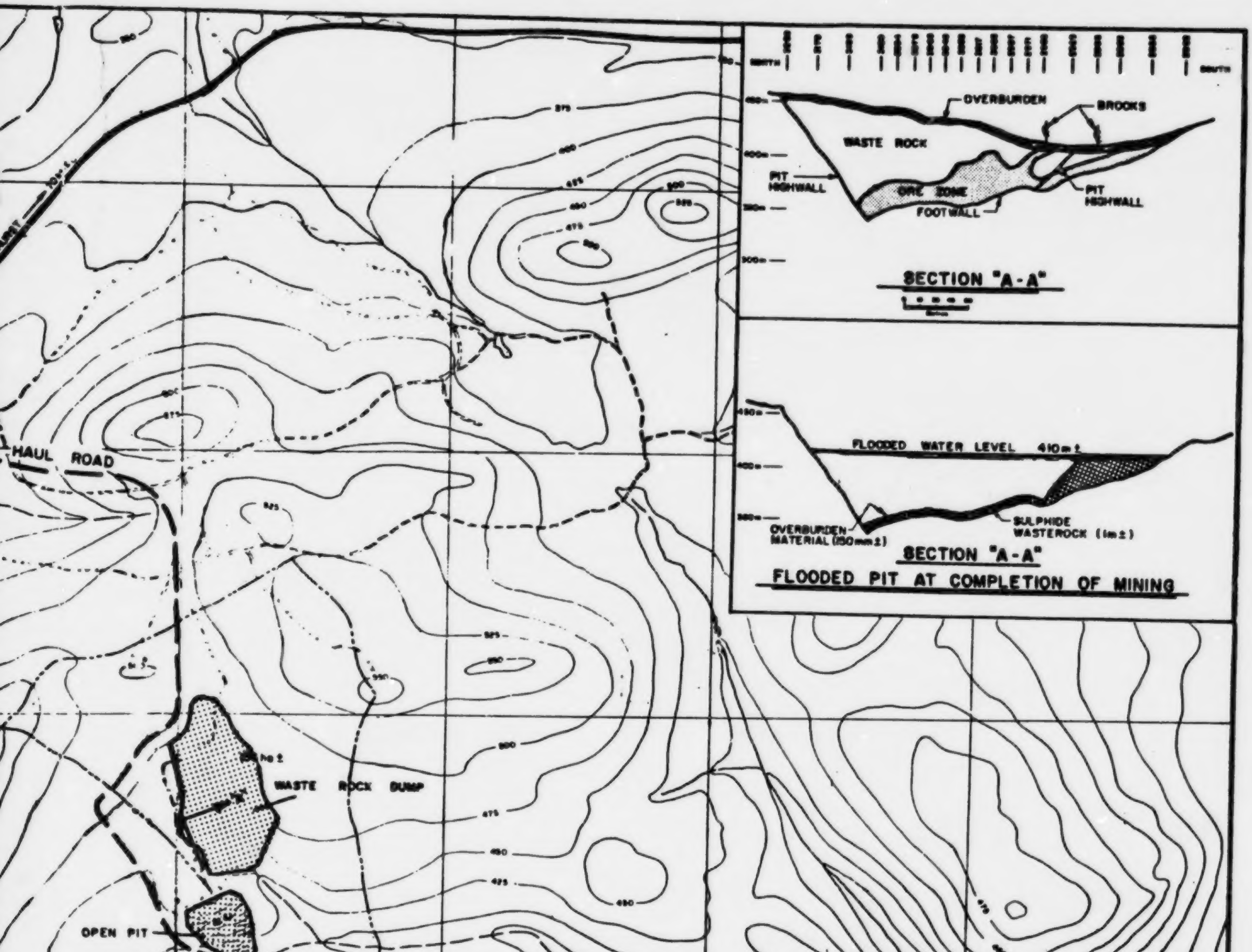
3.0 PROJECT DESCRIPTION

This section of the report considers the methods, facilities and infrastructure that will be required to extract the ore from the deposit, associated infrastructure, waste management facilities, off-site facilities including diversion of Charlotte Brook and construction of the mine haulage road and the associated reclamation plan. The general location for the minesite is shown in Figure 3-1. The environmental implications of the proposed mine operation are considered in subsequent sections of this report.

The shape and grade of the ore body dictate the use of open-pit mining to ensure viability of the operation. Thus, a quarry-like operation will be developed at the site. The overburden and "waste" rock overlying the ore zone will be excavated to expose the ore and the ore will then be removed. Blasting operations will be required to break the rock and enable its removal.

The quantity and grade of the ore body will not support an on-site "milling" operation to remove the economic minerals from the ore. Hence, a preliminary agreement has been reached with East West Minerals Ltd., owners of the mill at Caribou to process the ore and additional provision has been made for milling at Heath Steele, if necessary. The ore will be hauled by truck along the existing upgraded access road to Highway 180.


PROVINCIAL ROUTE 180 TO BATHURST
HAUL ROA
THIRD PORTAGE LAKE
SECOND PORTAGE LAKE
FIRST PORTAGE LAKE
224 ha ±
DRAINAGE DIVIDE
NORTH STREAM
SCALE -
800
0
800 metres


HAUL ROAD
WASTE ROCK DUMP
OPEN PIT
CHARLOTTE BROOK
172ha±
"A"
OVERBURDEN
BROOKS
WASTE ROCK
PIT HIGHWALL
ORE ZONE
FOOTWALL
PIT HIGHWALL
NORTH
SOUTH
450m
400m
350m
300m
SECTION "A-A"
FLOODED WATER LEVEL 410m±
OVERBURDEN MATERIAL (150mm±)
SULPHIDE WASTEROCK (1m±)
SECTION "A-A"
FLOODED PIT AT COMPLETION OF MINING
475
450
425
400
375
350
325
300

NOTE
DISTANCE ALONG CHARLOTTE BROOK TO UPSALQUITCH LAKE FROM SITE IS 4.3KM±

FIGURE 3-1

MARSHALL MINERALS CORPORATION

RESTIGOUCHE PROJECT
LOCATION

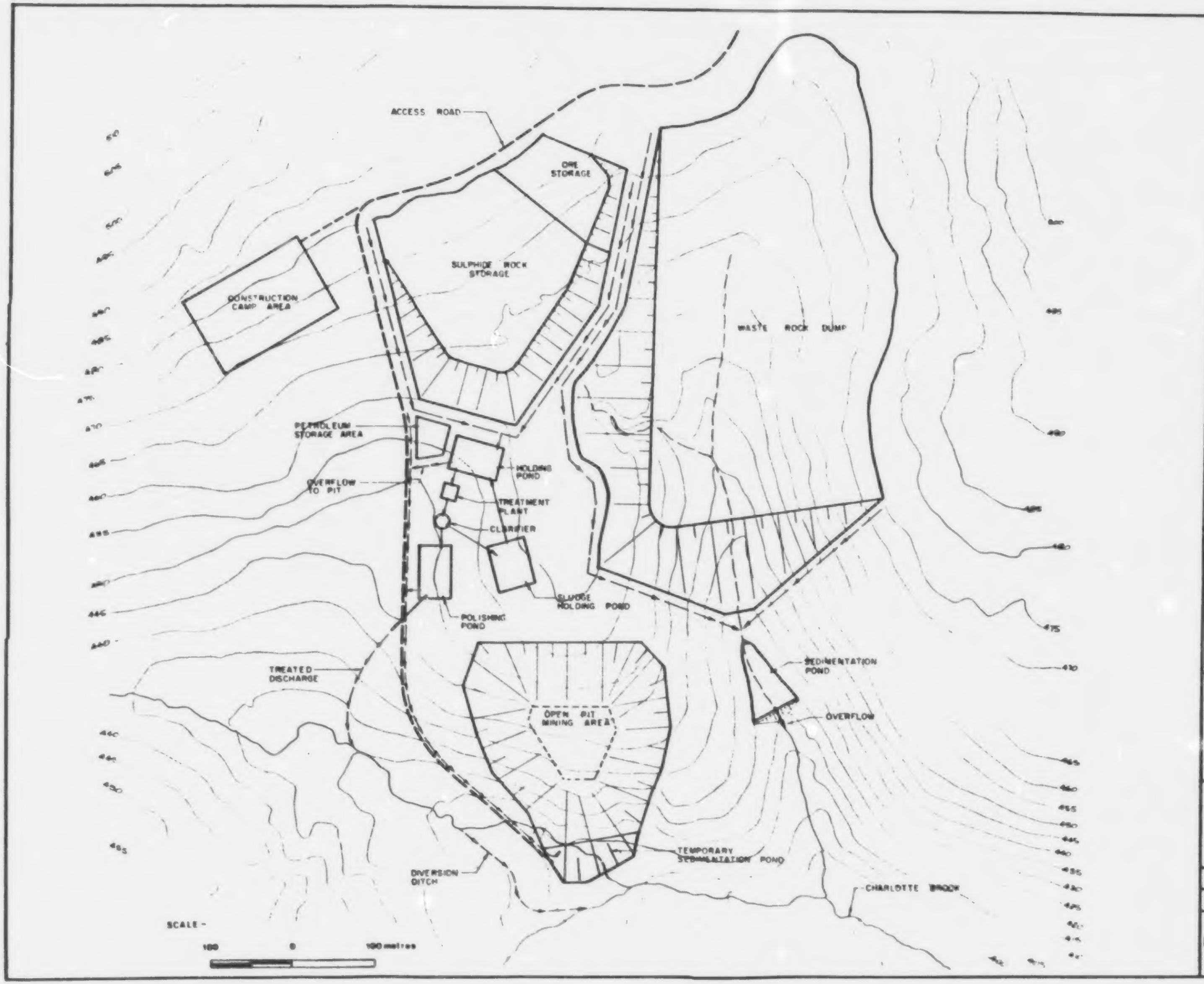
DATE	JULY 1989	SCALE	1:10,000	DWG NO.	001-D-03	REV NO.	1

3.1 Mine Plan

The ore body is estimated to contain approximately 1 million tonnes of ore. To remove this ore, approximately 6 million tonnes of overlying waste rock will have to be excavated. The ore and waste rock will be extracted during a 3 to 4 year period, the expected lifetime of the proposed mine development.

The ore reserves were calculated manually from sections produced by computer. All data were loaded into the PC-EXPLOR program and plotted as windowed sections at 1:250 scale. The shapes of the mineralized lenses were outlined by hand, based upon Marshall's interpretation of geology. Two Pb + Zn cut-off grades were evaluated (6% and 8%) and the reserve figures given above were calculated at the 8% Pb + Zn cut-off grade. Standard planimeter techniques were used to measure areas. Volumes were estimated assuming continuity halfway to the adjacent sections, tonnages were derived using measured specific gravity data and the grades were assigned by averaging the data from the drill holes intersecting any particular block.

The approximate maximum extent of the open pit is shown in Figure 3-2. The pit will have a maximum surface area, at ground level, of 5 hectares and a maximum depth of 110 metres at its northern limit. The near-surface ore underlies Charlotte Brook and rises to ground level just south of the brook. In order to avoid any major disturbances to Charlotte Brook, most of this ore will not be removed. The north branch of Charlotte Brook will however, be diverted into the south branch to enable removal of the bulk of the ore north of the south branch.


ACCESS ROAD
ORE STORAGE
SULPHIDE ROCK STORAGE
CONSTRUCTION CAMP AREA
WASTE ROCK DUMP
PETROLEUM STORAGE AREA
HOLDING POND
OVERFLOW TO PIT
TREATMENT PLANT
CLARIFIER
SLUDGE HOLDING POND
POLISHING POND
TREATED DISCHARGE
OPEN PIT MINING AREA
SEDIMENTATION POND
OVERFLOW
TEMPORARY SEDIMENTATION POND
DIVERSION DITCH
CHARLOTTE BROOK
SCALE -
100
0
100 metres

5			
4			
3			
2			
1	PRELIMINARY		

WASHBURN & GILLIS ASSOCIATES LTD

MARSHALL MINERALS CORPORATION
RESTIGOUCHE PROPERTY
NEW BRUNSWICK

GENERAL ARRANGEMENT

PEJ
22 JAN 90

MMD-90-1

FIGURE 3-2

The waste rock and ore will be broken by drilling and blasting, using both ammonium nitrate-fuel oil based explosives and high explosives (i.e. dynamite). Explosive demands will be approximately 0.20 kg/tonne for the ore zone and 0.19 kg/tonne for the waste rock. High explosives will be delivered in truckloads and stored in an approved powder magazine. Approximately 2,000 kg of such explosives will be maintained at the site (for 10 days of operations). Ammonium nitrate explosives will be transported and maintained in tanker trucks. The objective of the drilling and blasting will be to produce ore of less than 50 cm maximum dimension. This is the upper size limit acceptable at the Caribou mill.

The broken rock in the pit will be loaded into 35 tonne capacity off-highway trucks by front end loaders for transfer to the waste rock disposal areas or to an ore dump station at the northern end of the minesite. Ore will then be loaded from the dump station into 25 tonne capacity highway trailers for transfer to the off-site mill. Three trucks will be required to convey 750 to 800 t/d of ore to the mill in three shifts.

A total of 55 persons will be required for the mine and truck haul operation. Training, safety and health matters related to the operations will be in accordance with conventional mining industry practices and requirements of the Occupational Health and Safety Commission.

3.1.1 Development Plan

The overall development plan for the project, assuming approval for its implementation by the Province by early 1990, is summarized in Table 3-1.

TABLE 3-1

Overall Development Plan

Item	Time Period
Complete designs/reports and apply for approvals including: - Feasibility study (Mining Act) - Reclamation plan (Mining Act) - Approval to Construct (Clean Environment Act) - Watercourse Alteration Permit for stream diversion (Clean Environment Act) - Mining Lease - Crown lands Lease	December 1989/January/ February 1990
Finalize construction documents, obtain construction bids, order equipment	March/April, 1990
Construct Access Road	May, 1990
Construct Site Facilities and Stream Diversion	May/June/July, 1990
Phase I Bulk Sampling/Milling Trials	June/July/August/ September/October, 1990
Phase II Initiate Open-Pit Mining	November, 1990

3.1.2 On-Site Facilities

Facilities at the site will include:

- site access roads;
- the open pit;
- main waste dump for overburden/non-acid generating waste rock disposal;
- diversion and collection ditches;
- sedimentation pond;
- ore and sulphide rock storage area;
- contaminated drainage holding pond;
- treatment plant and polishing ponds;
- service buildings including office, warehouse, repair shop, storage rooms, dryhouse and first aid room (these will be located near the pit);
- topsoil storage area;
- potable water supply well;
- septic tank sewage disposal system;
- diesel generator for power supply;
- petroleum storage area for 40,000 litres of diesel fuel (installed to meet requirements of the Province's "Petroleum Products Storage and Handling Regulations);
- explosives storage area, and
- camp area.

A garbage dump will not be maintained at the site. Domestic garbage will be hauled to one of the Province's approved disposal sites such as that developed by the Nepisiquit Chaleur Solid Waste Commission at Red Pine Station (approximately 90 km).

3.2 Waste Management Plan

The Restigouche ore body is a massive sulphide deposit and consequently has the potential to generate acidic, metals-bearing drainages. Oxidation of the sulphides to produce sulphuric acid and soluble metals would occur upon break-up of the deposit and its exposure to air and water (vapour or moisture), the essential reagents necessary for the oxidation process to occur (Environment Canada, 1987). These contaminants, which are generated on the surfaces of the sulphides, are easily dissolved into rainfall, surface runoff and groundwaters which come directly or indirectly into contact with the sulphides. The uncontrolled loss of these contaminated and highly-toxic drainages can result in severe damage to the terrestrial and aquatic environment near to and, in many situations, at greater distances from a minesite. Hence, the minimization, containment and treatment of these drainages are the major waste management concerns associated with potential development of a mine at the Restigouche site.

3.2.1 Potential for Acid Generation

The deposit can be divided into three zones with respect to sulphide content. The "hanging wall" rock, which overlies the ore, contains less than 1 wt% sulphides and in this regard is similar in composition to inert bedrock. The ore zone generally contains in excess of 90 wt% sulphides. The "footwall" rock which underlies the ore contains as much as 10 wt% sulphides. The potential of these various rock types to generate acid was confirmed by measurement of sulphur content and acid consumption capability of 74 samples of rock obtained from samples of drill hole core at critical locations throughout the deposit. The results of the analyses are given in Appendix C.

From Appendix C it will be seen that the footwall rock is, with rare exceptions, acid generating whereas the hanging wall rock is, with rare exceptions, acid consuming. The acid generating capacity of the footwall rock is due to their sulphide content, and the testwork carried out to date has determined a correlation between visual estimates of 2-1/2 to 3% or more sulphides (i.e. more than 1% S; see Appendix C) and potential for acid generation. The acid consuming capacity of the hanging wall rock is probably derived from the presence of interstitial, late calcite in the felsic tuffs and volcanics. This is a relatively common constituent of such rocks and would be expected to impose a mildly alkaline pH upon groundwater passing through them (see Sections 4.1.4.3, 4.2.1.1 and 7.1).

Acid generation testwork carried out to date has determined a correlation between visual estimates of 3% or more sulphides and potential for acid generation. The results of exploration indicate that the various types of rock will be easily distinguishable during the mining process. In this context, holes 112-115 were drilled for the purpose of supplying samples for acid generation tests and to evaluate the possibility of visually estimating sulphides. The visual estimation of sulphides in their core logs slightly overstated the acid generating potential of the samples. Hole 113 was correctly identified as acid generating throughout, holes 114 and 115 were correctly identified as non-acid generating throughout, but hole 112 was identified as being acid generating throughout when only the top 15 m (total depth 24 m) of the hole proved to be so. Based on these data careful geological logging and assaying will enable the non-acid generating inert rock to be separated from the rock that has potential for acid generation.

At the completion of mining operation, the eastern side of the open pit will contain some rock with a potential for acid generation. The northern perimeter of the pit will contain inert rock, while the bottom of the pit will have potential for the generation of acidic drainages. These factors will influence the methods to be used for the long-term reclamation of the area.

3.2.2 Potential Sources of Waste

The potential sources of waste from the proposed open-pit mine include:

1. inert waste rock;
2. acid generating waste rock;
3. surface runoff from the inert waste rock disposal area;
4. surface runoff from the acid generating waste rock disposal area;
5. minewater pumped out of the open pit;

6. sewage generated by a workforce of 55 persons;
7. miscellaneous scrap and garbage; and
8. fuel and lubricant oils.

The succeeding sections consider items 1 to 5. Sewage will be treated by a septic tank system or an equivalent method approved by the Province. Miscellaneous scrap and garbage will be disposed of at one of the Province's approved waste disposal sites (as noted in Section 3.1.2). Oil wastes will be disposed of through a qualified waste oil facility.

3.2.3 Waste Handling and Treatment

A waste rock management strategy has been developed whereby the various types of waste rock can be managed in an optimum manner with respect to environmental considerations. The amount of acid generating waste rock removed from the pit will be minimized by waste material management within the pit, resulting in much of this waste remaining in the pit. This will also allow material that has been removed to be returned to the pit more efficiently (see Section 3.4). Waste materials removed from the pit will be placed on unifill pads, separating the inert and acid generating wastes, providing increased drainage control. Waste control will further be enhanced by inspection of drilled material, bench mapping, and inspection of material following blasting.

The major facilities that will be located at the site and the proposed systems for the collection and treatment of acidic drainages are shown in Figure 3-2. All facilities related to the storage of acid generating waste rock and the control and treatment of drainages will be located upgradient of the open pit. The drainage control and treatment systems will be designed and installed to ensure that any accidental or otherwise unacceptable drainages flow into the open pit. This basic criterion for the layout of the site will ensure that no drainages from the site enter Charlotte Brook unless they are of acceptable quality.

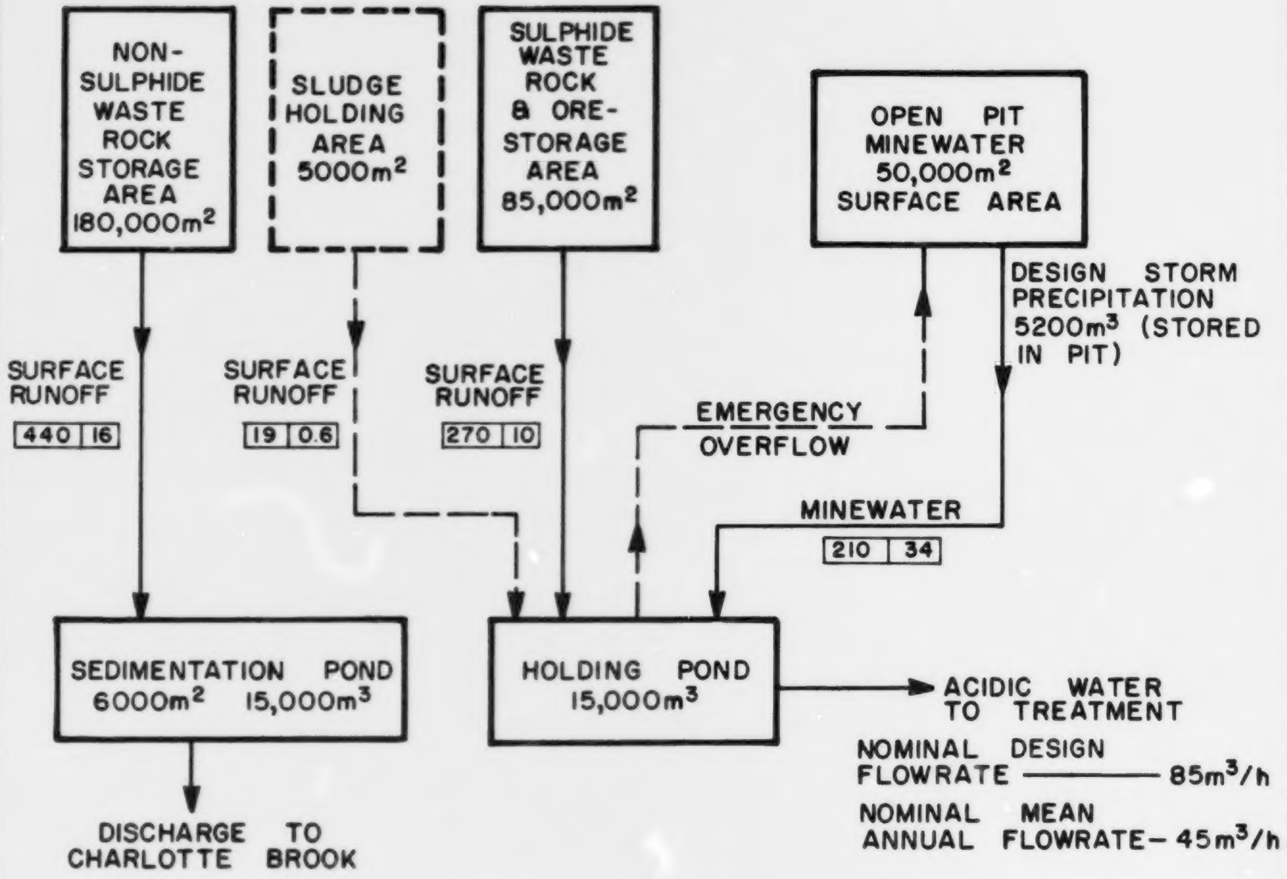
The drainage control and treatment facilities for the management of acidic drainages will consist of the sulphide waste rock and ore storage pad, a dewatered sludge storage area, a holding pond for the collection of runoff from the pad, and the wastewater treatment equipment and related ponds.

As shown in Figure 3-2, the main waste rock dump, containing non-acid generating rock, will be east of the open pit. Drainage from this area will flow through a sedimentation pond prior to being discharged into the brook. The sedimentation pond will provide a retention time of 12 hours, under design conditions, to ensure the removal of settleable solids.

The primary source of acidic drainage will be minewater pumped from the open pit and runoff from the ore and sulphide waste rock storage pads. The rate of acid generation from the waste rock storage pads will be minimized by the addition of powdered or slurried lime to the rock as it is dumped onto the area. Ore will be hauled to the off-site concentrator as it is mined. However, nominal storage capacity for ore will be provided at the minesite to balance the truck haul operation. The sulphide waste rock and ore storage area and the sludge storage area will be lined with compacted till to provide a liner of very low permeability. Runoff from these areas and from the dewatered sludge disposal area will drain into a similarly lined holding pond.

Minewater, pumped from the open pit, will also flow into the holding pond. Water collected in the holding pond will flow by gravity into a treatment system for the reduction of acidity and heavy metals prior to discharge into the polishing ponds and release into Charlotte Brook. The holding pond will have adequate capacity to contain the storm runoff from the sulphide waste rock and ore storage area for a 20 year return - 24 hour duration rainfall. During such extreme storm conditions, minewater would not be pumped from the open pit. If the capacity of the holding pond is exceeded, overflows will be discharged into the open pit, as indicated in Figure 3-2. Design and average flowrates for the various sources of drainages are given in Figure 3-3.

Soil tests have indicated that local surficial materials can be used for construction and lining of the various ponds, related ditches and storage pads. Mean in-situ moisture contents were comparable with optimum values for compaction. The


NON-SULPHIDE WASTE ROCK STORAGE AREA 180,000m²
SLUDGE HOLDING AREA 5000m²
SULPHIDE WASTE ROCK & ORE-STORAGE AREA 85,000m²
OPEN PIT MINEWATER 50,000m² SURFACE AREA
DESIGN STORM PRECIPITATION 5200m³ (STORED IN PIT)
SURFACE RUNOFF
440 | 16
SURFACE RUNOFF
19 | 0.6
SURFACE RUNOFF
270 | 10
EMERGENCY OVERFLOW
MINEWATER
210 | 34
SEDIMENTATION POND 6000m² 15,000m³
HOLDING POND 15,000m³
ACIDIC WATER TO TREATMENT
NOMINAL DESIGN FLOWRATE — 85m³/h
NOMINAL MEAN ANNUAL FLOWRATE — 45m³/h
DISCHARGE TO CHARLOTTE BROOK

NOTES

1. 4 | 0.8 ← MEAN ANNUAL FLOWRATE (m^3/h)
   ↑ DESIGN FLOWRATE (m^3/h)

2. DESIGN STORM RUNOFF - 20Y RETURN - 24H DURATION - 90 mm. HOLDING POND HAS CAPACITY TO CONTAIN STORM RUNOFF FROM SULPHIDE WASTE ROCK AND ORE STORAGE AREAS. STORM FLOWS INTO OPEN PIT WOULD BE CONTAINED IN PIT.

3. MEAN ANNUAL RUNOFF – 3mm/day

FIGURE 3-3

WASTEWATER PRODUCTION

earthwork structures will be lined to meet the equivalent of 1 m of 5×10^{-7} cm/s material (Environment Canada, 1985). Details will be provided in the application for approval to construct.

The flow diagram for the treatment of the acidic drainages is shown in Figure 3-4. The proposed treatment system provides the "best practical" technology (Environment Canada, 1987; MacDonald et al., 1989) for the removal of contaminant metals from the drainages. The treatment facilities will be designed for a flowrate of 85 m^3/h.

Requirements for the treatment system will primarily depend on the flowrate and acidity of the drainages that are actually encountered once mining commences. The flowrate and acidity of the minewater and runoff from the waste rock storage pad will gradually increase to site-specific values. This will occur as the exposure of sulphides is increased and the acid generation process becomes established. The time frame for this to occur can be measured in months. The addition of lime to the waste rock storage dump and the limited exposure of sulphides in the walls and bottom of the pit will reduce the loadings of acidity to the minewater and surface runoff from the waste rock storage pad.

In consideration of these site-specific factors, the treatment system will be installed in phases. The first phase, for which the flow diagram is shown in Figure 3-4, will be installed prior to the exposure of sulphide-bearing material. The system shown in Figure 3-4 will have all of the processes necessary to treat the required drainages. The need for

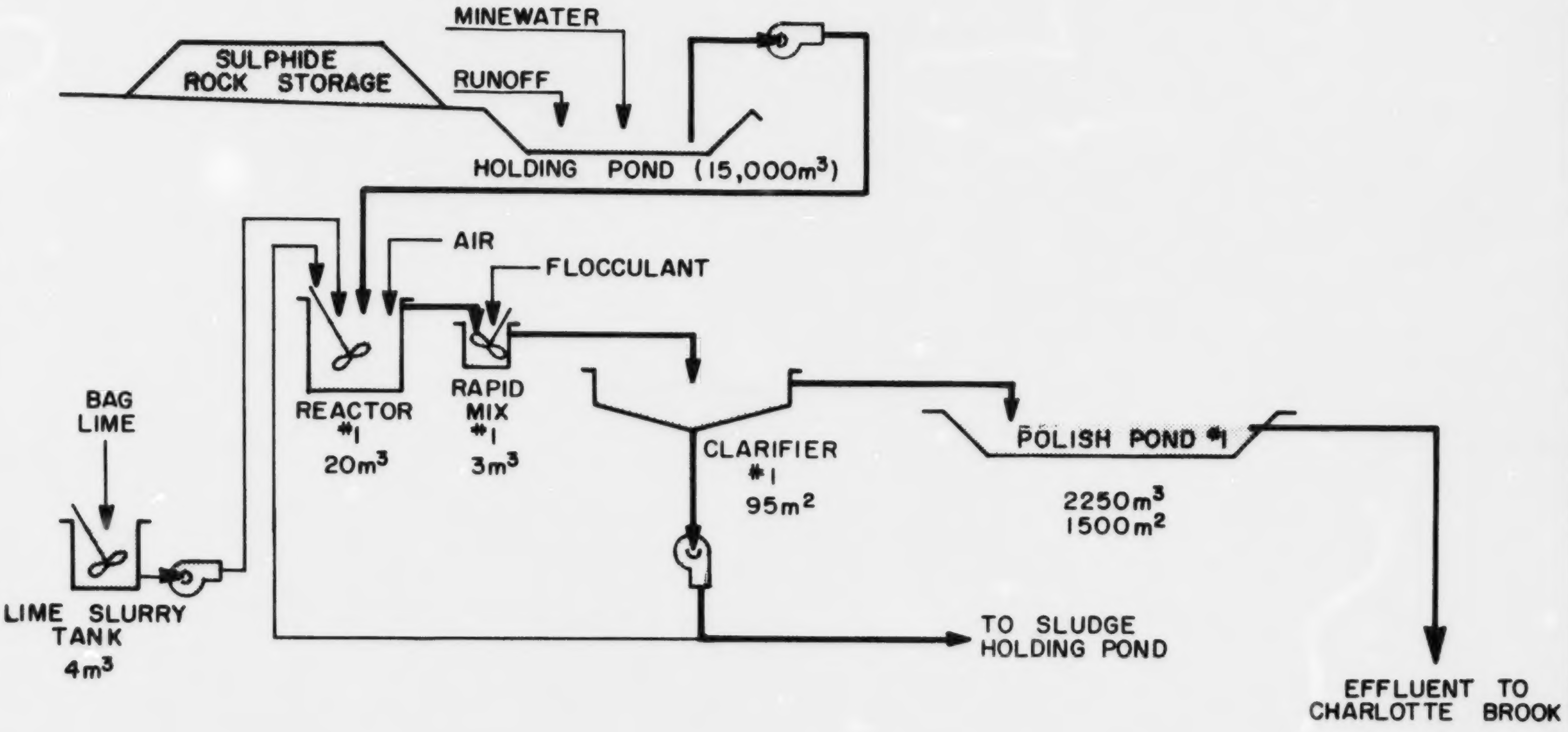

MINEWATER
SULPHIDE ROCK STORAGE
RUNOFF
HOLDING POND (15,000m³)
AIR
FLOCCULANT
BAG LIME
REACTOR #1 20m³
RAPID MIX #1 3m³
CLARIFIER #1 95m²
POLISH POND #1
2250m³
1500m²
LIME SLURRY TANK 4m³
TO SLUDGE HOLDING POND
EFFLUENT TO CHARLOTTE BROOK

FIGURE 3-4

FLOW DIAGRAM

INITIAL SYSTEM FOR ACIDIC WATER TREATMENT
DESIGN CAPACITY 85 m^3/h

installation of the second phase will be determined on the basis of trends in drainage characteristics observed during the first four months of operation. The second phase would consist of sludge dewatering equipment. At the projected flowrates of drainages, a trend in acidity towards total acidity values greater than 500 mg/l (as $CaCO_3$) would indicate the need for the second phase to enable practical management of sludge production (Table 3-2). The design and construction details for the whole system, as shown in Figure 3-5, will be developed prior to mining activity to ensure integration of the two phases and, more importantly, the ability to install the second phase, if required, within a few months.

The treatment of the sludge prior to its disposal will depend on the quantity that is generated and its chemical stability. It is likely that a gypsum-rich sludge will be suitable for ultimate disposal in the pit. If standardized testing (in accordance with Ontario Ministry of the Environment Regulation 309) of the sludge indicates that metals can be leached, then these metals will be removed from the sludge prior to its disposal. The treatment system will include a hydrochloric acid batch leach circuit to enable the removal of soluble metals (copper and zinc) from the sludge prior to its disposal on-site as an iron-rich gypsum sludge. The removal of soluble metals from the treatment sludges will produce the quantities of concentrate (copper-zinc rich, low iron content) shown in Table 3-3.

The leaching process will produce a stable gypsum iron-rich sludge, suitable for permanent disposal on-site, and a metals-rich concentrate. This concentrate can be disposed of in a secure containment facility on-site or "fixed" for permanent disposal at the site.

TABLE 3-2

Estimated Sludge Generation
(for mean annual flowrate - 45 m^3/h)

Acidity (mg/l as $CaCO_3$)	500	1500
Solids Production (t/year)	130	1100
Sludge Production		
- from ponds or clarifiers (m^3/year)	2400	20000
- from pressure filter (m^3/year)	800	6000

TABLE 3-3

Estimated Quantities of Concentrate
(for mean annual flowrate - 45 m^3/h)

Acidity (mg/L as $CaCO_3$)	500	1500
Concentrate after leaching (at 80 wt% solids)	25 t/a	200 t/a

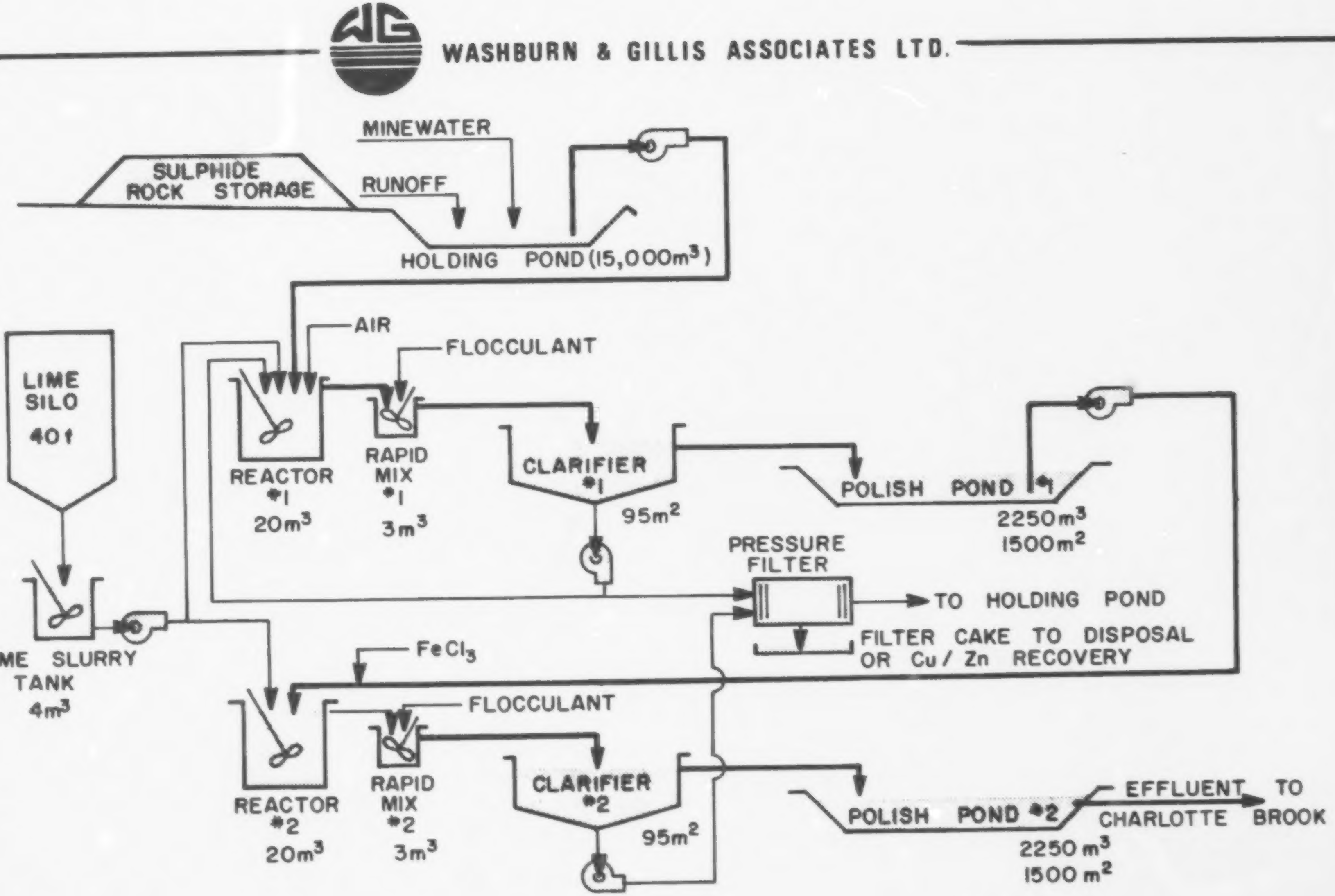

WASHBURN & GILLIS ASSOCIATES LTD.
MINEWATER
SULPHIDE ROCK STORAGE
RUNOFF
HOLDING POND (15,000m³)
AIR
FLOCCULANT
LIME SILO
40t
REACTOR #1
20m³
RAPID MIX #1
3m³
CLARIFIER #1
95m²
POLISH POND #1
2250m³
1500m²
PRESSURE FILTER
TO HOLDING POND
FILTER CAKE TO DISPOSAL OR Cu / Zn RECOVERY
LIME SLURRY TANK
4m³
FeCl₃
FLOCCULANT
REACTOR #2
20m³
RAPID MIX #2
3m³
CLARIFIER #2
95m²
POLISH POND #2
2250 m³
1500 m²
EFFLUENT TO CHARLOTTE BROOK

FIGURE 3-5
FLOW DIAGRAM
ACIDIC WATER TREATMENT SYSTEM
DESIGN CAPACITY 85m^3/h

SOURCE : K.D. PHINNEY, P.ENG.

The total system will, therefore, consist of three major elements:

1. A neutralization train for the precipitation of metal hydroxides, their separation from water, and collection of the resulting metals-rich sludge.

2. An adsorption train for the further removal of trace metals by their adsorption to ferric hydroxide floc, their separation from water, and collection of the resulting sludge.

3. A pressure filtration system to dewater the sludge to enable its storage and eventual disposal on-site.

It must be emphasized that development of the treatment system in phases is the only approach that can be technically and economically justified. The capital cost for the first phase, including all related site facilities (ponds, pads and ditches) will be in the order of $0.8 million. An additional $1.3 million investment would be required to install the second phase, a phase which, in our opinion, is unlikely to be required in order to obtain acceptable effluent water quality and to enable acceptable sludge management. The shape of the ore body and the proposed method of waste rock management are expected to result in "weakly" acidic drainages. For such conditions, the first phase treatment system will prove to be adequate. Observations during the initial phases of mine development and the availability of a completed design for the phase two treatment system will allow its installation prior to its actual need.

The various capacities given in Figures 3-4 and 3-5 for equipment and ponds are based on "conservative" design practices to ensure that effluent meets the required quality. The treatment system will be designed for all-weather operations. Automatic pH and turbidity controls will be used to regulate and monitor the operation. These controls will be designed to initiate alarms and automatically prevent discharge of "off-spec" effluents into Charlotte Brook.

Treated effluent will be discharged on a routine basis into Charlotte Brook. The estimated quantities of effluent are given in Table 3-4 for various runoff/precipitation conditions. The effluent will consist of an alkaline calcium sulphate solution with traces of

TABLE 3-4

Nominal Effluent Flowrates - Operating and After Reclamation

Source	Low Flow Periods	Mean Annual	Spring Period	Summer Period
	m^3/h	m^3/h	m^3/h	m^3/h
Non-acid generating waste rock area	0(0)	20(20)	80(80)	10(10)
Sulphide waste rock and sludge disposal area	0(-)	11(-)	19(-)	1.7(-)
Minewater	5.4(5.4)	34(14)	66(44)	30(10)

NOTE: 20(20) - flowrate operating phase - 20 m^3/h (flowrate after reclamation - 20 m^3/h)

various metals, including iron, zinc, copper and lead. The quality of the effluent will meet the requirements of the Metal Mining Liquid Effluent Regulations (Environment Canada, 1977; see Section 6.1.1.1).

3.3 Off-site Facilities

Adequate waste management infrastructure is incorporated in the Caribou and Heath Steele facilities for milling of Restigouche ore (see Section 2.4.2). Off-site facilities directly related to the development of the Restigouche property include the diversion of the north branch of Charlotte Brook and the mine haulage road.

3.3.1 Diversion of North Branch of Charlotte Brook

The diversion of the north branch of Charlotte Brook into the south branch will provide access to the majority of the ore body while minimizing disturbances to the existing brook. The diversion will provide habitat of equal quality to that of the north branch and will be located approximately 60 m from the western perimeter of the open pit (see Section 6.2.1.1). The diversion will be designed to have a somewhat lower slope than the section of the brook which would be replaced. The diversion will be designed as a lined, stone/gravel-paved channel to minimize erosion and to ensure initial and permanent stability with respect to loss of sediment. The channel will be designed to incorporate various fish habitat improvement structures. Design and construction details for the diversion will be provided as part of the application for a Watercourse Alteration Permit.

3.3.2 Haulage Road

The existing roads in the Restigouche site area, while adequate for the servicing of an exploration operation, are inadequate for fuel and ore haulage. There are locally steep gradients and tight corners which could lead to potentially hazardous operation of loaded trucks.

Accordingly, Marshall has selected a new routing of the haulage road which follows the existing access road where practical but eases gradients and curves for safer operation. It crosses no streams and emerges on Highway 180 very close to the existing site access road (Figure 3-6).

The new alignment will be built to the specifications of main haulage forestry roads, and will be capable of being used year round. It will be properly signposted at Highway 180 and, although access will not be restricted, notices warning of the use of the road by loaded haulage trucks will be posted.

3.4 Reclamation Plan

At the completion of mining, prematurely or upon exhaustion of the ore, the site will include the open pit, the waste rock storage areas, various ponds, foundations, roads, and buildings. The site could not be immediately abandoned under these conditions due to:

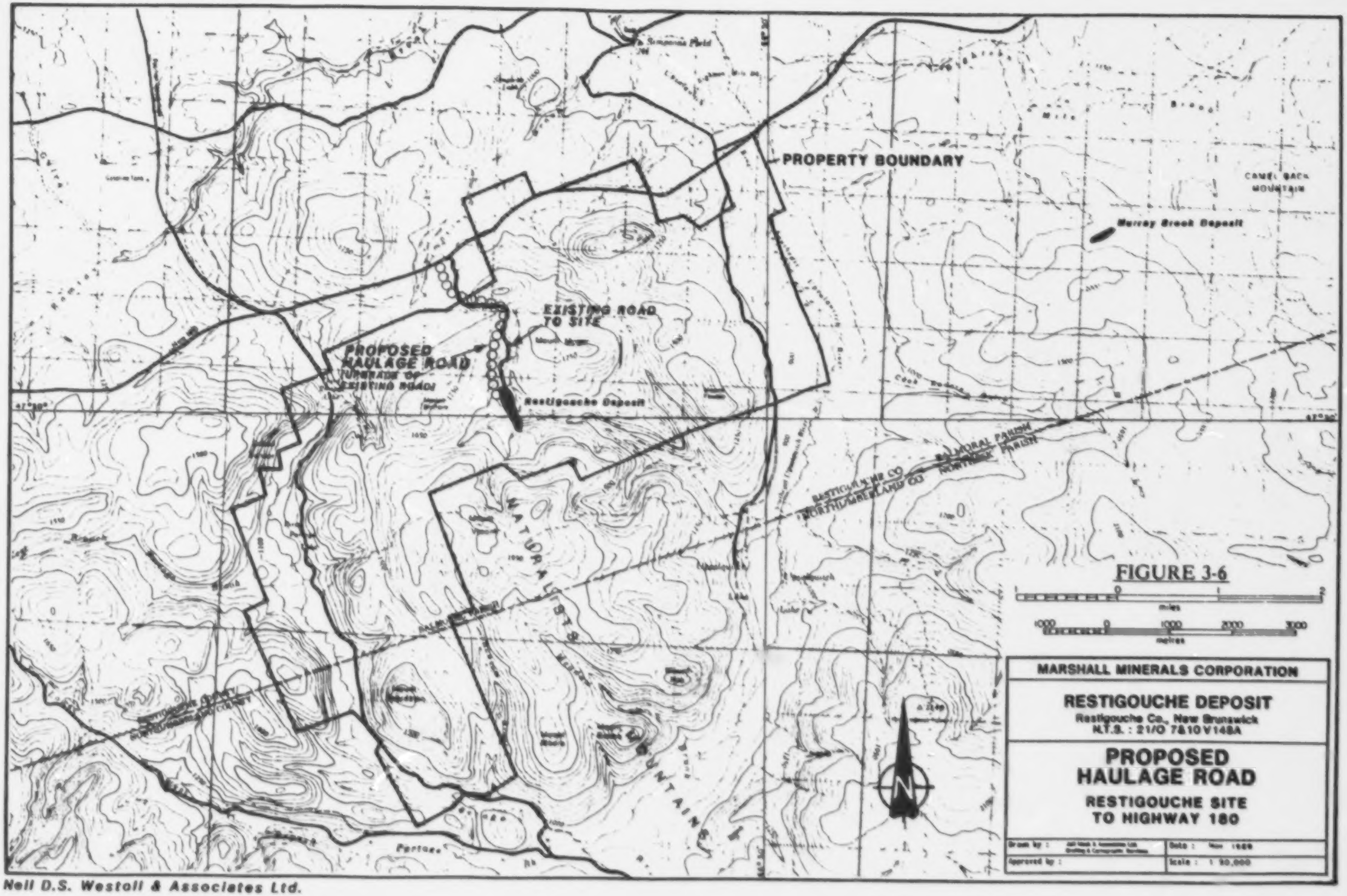

PROPERTY BOUNDARY
CAMEL BACK MOUNTAIN
Murray Brook Deposit
EXISTING ROAD TO SITE
PROPOSED HAULAGE ROAD (UPGRADE OF EXISTING ROAD)
Restigouche Deposit
NATURALISTS MOUNTAINS
RESTIGOUCHE CO
NORTHUMBERLAND CO
BALMORAL PARISH
NORTHESK PARISH
Portage
N
miles
0
1
2
metres
1000
0
1000
2000
3000

FIGURE 3-6

MARSHALL MINERALS CORPORATION

RESTIGOUCHE DEPOSIT
Restigouche Co., New Brunswick
N.T.S. : 21/O 7&10 V148A

PROPOSED
HAULAGE ROAD

RESTIGOUCHE SITE
TO HIGHWAY 180

Drawn by : Neil Westoll & Associates Ltd. Drafting & Cartographic Services
Date : Nov 1989
Approved by :
Scale : 1 : 50,000

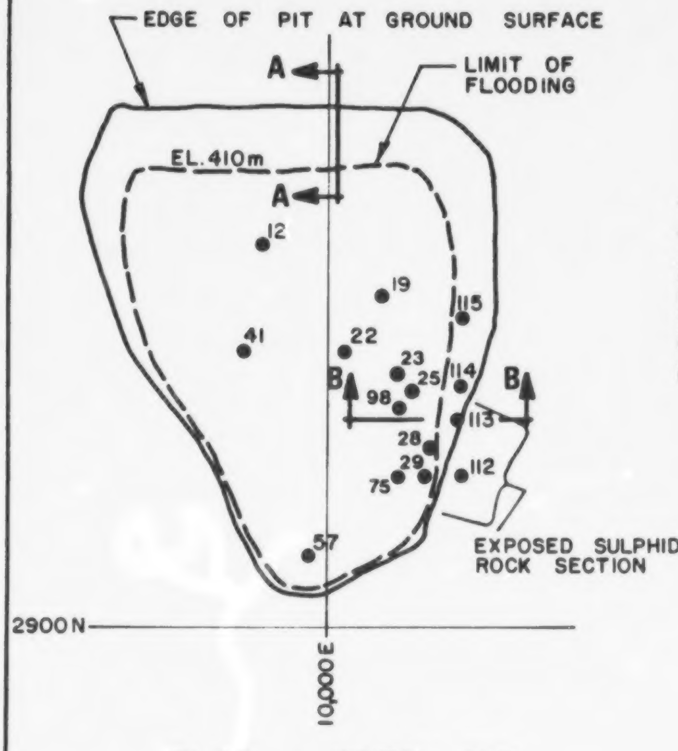
Neil D.S. Westoll & Associates Ltd.

- the potential for continued generation of acidic drainages;
- poor aesthetic quality and unsafe conditions due to the remaining structures.

Hence, reclamation measures will be required to ensure that the site can be permanently abandoned in a stable, safe and aesthetically acceptable condition.

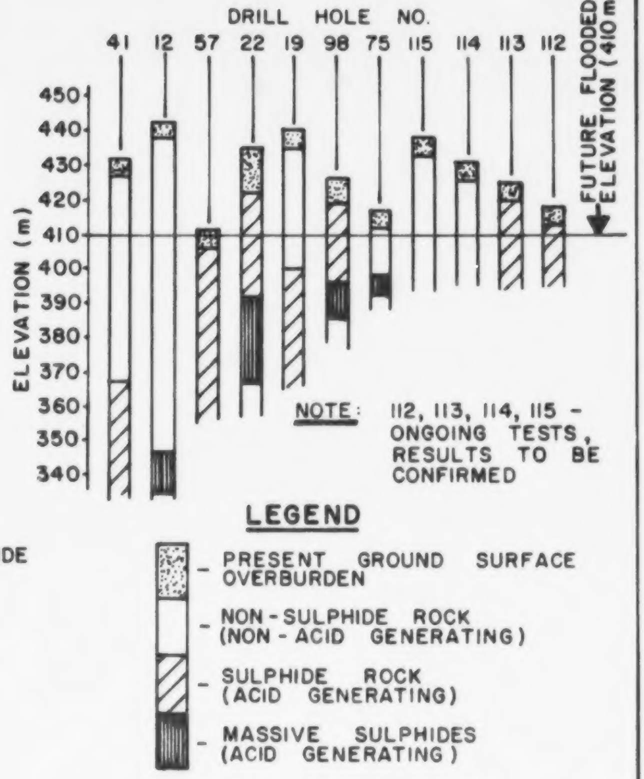
The open pit and inert waste rock dump will remain as permanent features of the area. The waste rock dump will be contoured, covered with a layer of topsoil and revegetated. The open pit will be allowed to flood to an overflow level equivalent to the level of Charlotte Brook at the site. Thus, the open pit will remain as a permanently flooded area. All mineralized rock will be either under at least 1 meter of water or safely protected from exposure to oxygen. This may require special measures to be taken at the south end of the pit before it is allowed to be flooded. The highwall sides of the pit will be sloped, wherever required, to ensure a gradual grade into the pond. The general features of the pit at a flooded elevation of approximately 410 m is shown in Figure 3-7.

All rock, and any iron-gypsum sludge, stored in the sulphide waste rock area will be transferred to the bottom of the open pit prior to allowing it to flood. This acid generating material will be spread out along the bottom of the pit and then covered with overburden (at least 150 mm thick). The overburden will create a diffusion control barrier


EDGE OF PIT AT GROUND SURFACE
LIMIT OF FLOODING
A
A
EL. 410m
12
19
115
41
22
23
114
25
B
B
98
113
28
29
75
112
57
EXPOSED SULPHIDE ROCK SECTION
2900N
10,000E

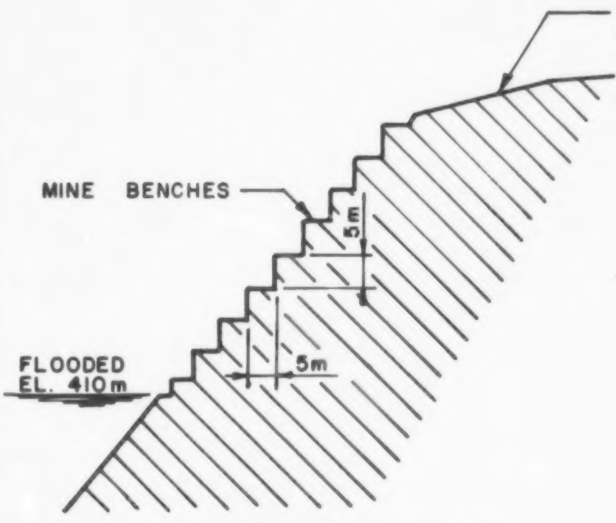
PLAN - OPEN PIT

1:4000



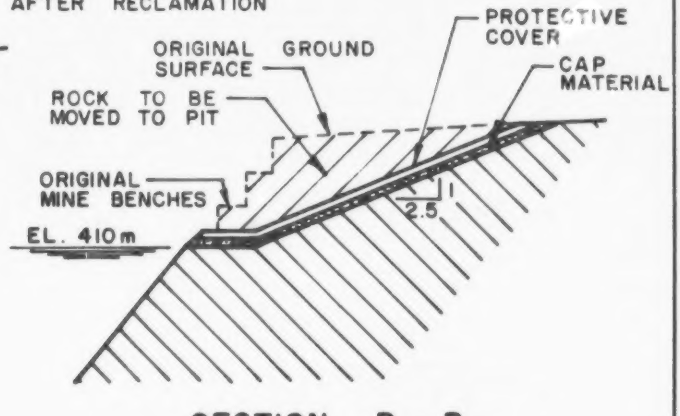
DRILL HOLE LOGS

1:2000


GROUND SURFACE AFTER RECLAMATION
MINE BENCHES
5m
FLOODED EL. 410m
5m

SECTION A-A

PIT WALL RECLAMATION
(NON-SULPHIDE ROCK)
1:1000


PROTECTIVE COVER
ORIGINAL GROUND SURFACE
CAP MATERIAL
ROCK TO BE MOVED TO PIT
ORIGINAL MINE BENCHES
1
2.5
EL. 410m

SECTION B-B

PIT WALL RECLAMATION
(SULPHIDE ROCK)
1:1000

FIGURE 3-7
RECLAMATION PLAN
FOR OPEN PIT

SOURCE: K.D. PHINNEY, P.ENG.

between the sulphide waste rock and the overlying pool of water. This will eliminate the sulphide waste rock becoming a future source of acid generation due to the effectiveness of a water barrier in minimizing the rate of transfer of oxygen to the sulphides (Environment Canada, 1987).

The planned sequence of mining in the open pit will allow the dumping of acid generating waste rock in the worked-out, southern part of the pit while mining continues in the northern part. This will permit the disposal of some acid generating waste rock directly into the pit, as it is mined, and will also permit trucks hauling ore and inert waste from the pit to return carrying acid generating waste thereby significantly reducing overall cost of rehandling the acid waste material. A preliminary mining schedule, which is summarized in Table 3-5, indicates that all acid waste material can be returned to the pit prior to the completion of the mining program.

As noted in Section 2.2.2 the country rock below the massive sulphides at Restigouche is characterized by the presence of up to 10% of disseminated sulphides, mainly pyrite, in a "stringer zone". The stringer zone is confined to the area immediately below the massive sulphides and, while it is known to extend to considerable depths, it extends laterally only a short distance from the edges of these sulphides. When the pit is mined out and allowed to flood, any sulphide-bearing rock exposed in the walls of the flooded pit above 410 m will have the potential to be acid generating.

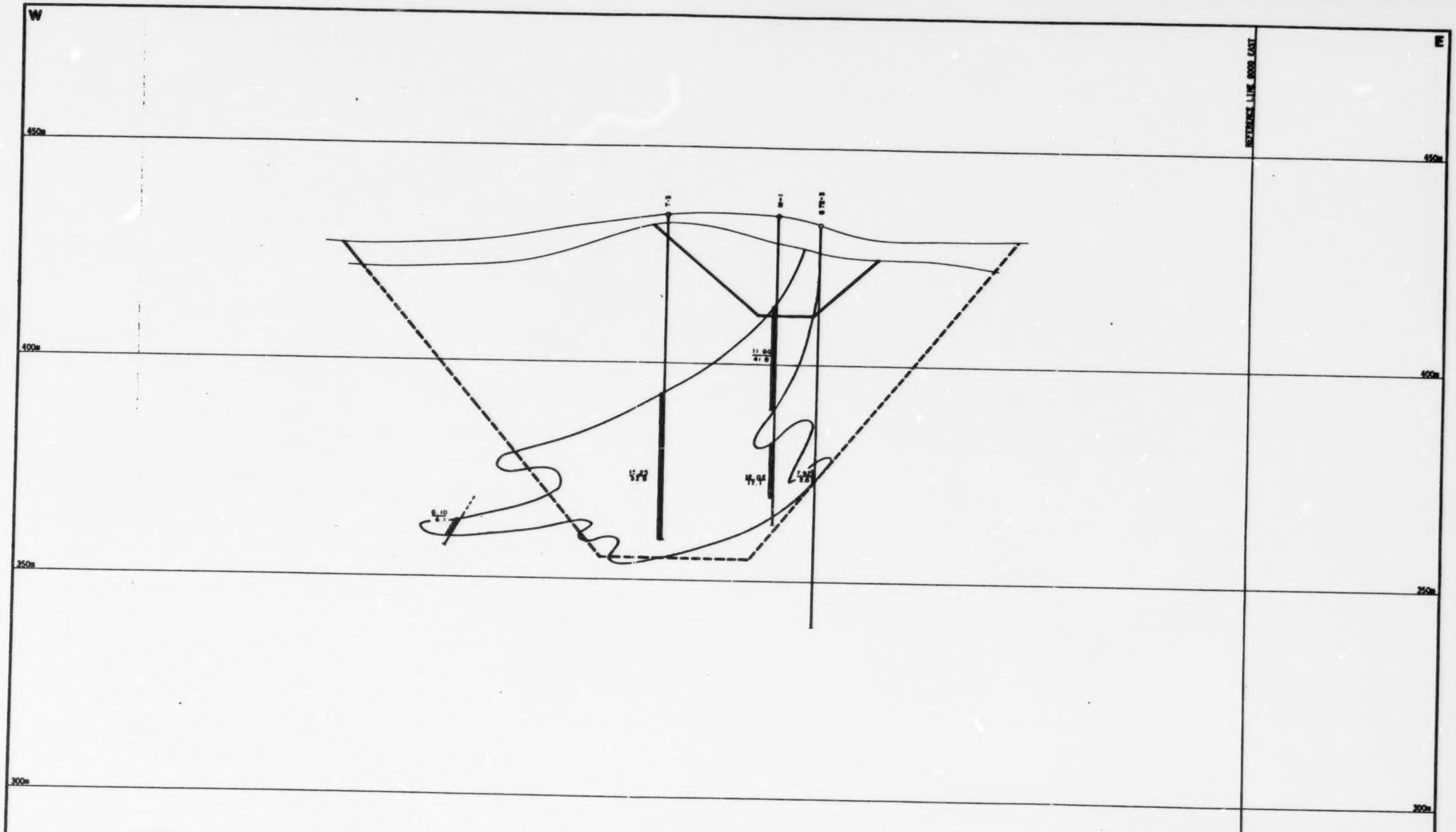
TABLE 3-5

RESTIGOUCHE PROJECT
PRELIMINARY MINING SCHEDULE SUMMARY

	MATERIAL MOVED			TOTAL ON DUMP		PLACED IN PIT	
QUARTER	ORE	ACID WASTE	WASTE	ACID WASTE	WASTE	ACID WASTE	WASTE
pre-prod	0	80	381	80	381	0	0
1	103	100	425	180	306	0	0
2	130	84	462	264	1,268	0	0
3	0	0	539	264	1,807	0	0
4	106	97	454	361	2,261	0	0
5	90	50	439	411	2,700	0	0
6	90	45	440	456	3,149	0	0
7	90	45	432	501	3,572	0	0
8	75	40	437	541	4,009	0	0
9	78	21	471	406	4,480	156	0
10	75	20	480	271	4,960	155	0
11	80	20	475	135	5,435	155	0
12	79	22	457	0	5,392	157	0
TOTAL	996	624	5,892			624	0

The Restigouche sulphide body plunges to the north at approximately 25° and dips to the west at variable angles between 30° and 50°. Consequently, the potentially acid generating footwall sequence lies well below the flooded pit limits on the north and west sides of the deposit, as shown in cross-section in Figure 3-8. The hanging wall rock exposed on the north and west sides of the flooded pit contains less than 1% sulphides (by visual estimate - see Section 3.2.1). They are the same sequence of rocks which comprise the upper parts of holes 12 and 41, and are not therefore expected to be acid generating. At the southern end of the deposit the floor of the pit, which is sulphide-bearing, will lie below the flooded pit level (Figure 3-7).

There is, however, some potential for the generation of acidic drainages along a portion of the eastern side of the final pit. The results of the acid generation tests indicate that an approximately 50 m to 60 m length along the eastern perimeter of the pit will contain exposed sulphide rock after flooding of the pit. The location and extent of this section is shown in Figure 3-7. On the basis of present data (Appendix C), Marshall expects that the sulphide-bearing rock in this area will extend only for a limited distance to the east of the pit crest, and the company intends to remove the sulphide-bearing material above the flooded pit level and deposit it in the bottom of the pit, together with other potentially acid generating waste (as noted earlier in this section), before it is allowed to flood. If the sulphide-bearing rock extends continuously to the east from the pit crest, the volume of rock concerned could become very large and the cost to mine it and deposit it in the pit would become correspondingly high. In this circumstance, Marshall will ensure


W
E
REFERENCE LINE 8000 EAST
450m
400m
350m
300m

LEGEND

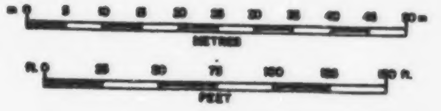
☐ Massive Sulphides

% Combined PbZn / metres

Initial Pit

Ultimate Pit

FIGURE 3-8


METRES
FEET

REVISED	**MARSHALL MINERALS CORPORATION**	
	RESTIGOUCHE DEPOSIT Restigouche Co., New Brunswick N.T.S. : 21/O 7&10 V 148A	
	SECTION 3033m N FACING GRID NORTH	
PROJECT #		
DRAWING # 13	Drawn by : Approved by :	Date : SEPT Scale :

NEIL D.S. WESTOLL & ASSOCIATES LTD.

that this section will be sloped towards the pit and sealed with impervious material as shown conceptually in Figure 3-7. An engineered seal will be specified to ensure minimal access of air and water. The seal will consist of a liner of very low permeability protected with a cover material, topsoil and vegetation to ensure permanent stability. Detailed design parameters for liners and seals will be provided in the application for approval to construct.

Hole 57 (identified in Figure 3-7) lies within the pit at a point that will be excavated to an elevation of approximately 370 m. The sulphides shown in Figure 3-7 to occur at a depth of 406 m in hole 57 would therefore, be well below the flooded level of 410 m when excavated to the pit floor. From careful examination of the drill logs for all the holes in the southern portion of the deposit, it is clear that all sulphides at the southern edge of the pit itself will be covered by at least 4 m to 5 m of water when the pit has been flooded to the 410 m level. Furthermore, since the floor of the pit then slopes 45° to the north from the southern edge, water cover over the sulphides will increase appreciably to the north. There is therefore, no likelihood that potentially acid generating rocks will remain exposed above the water level when the pit has been flooded.

The reclamation of the site will be completed by the removal of all structures, filling in of all ponds, stabilization of a section of the east wall of the pit if required, flooding of the open pit, contouring and covering of the inert waste dump with soil, and contouring and seeding of the disturbed area to re-establish vegetation. The haulage road will not be disturbed unless required by the Province. The proposed reclamation plan can be carried out at any stage during the development of the mine.

3.5 Project Costs

3.5.1 Cost of Development

Marshall has yet to make a decision on whether it will mine the Restigouche ore itself or engage a contractor to do so. The data required for this decision are being generated as part of the feasibility study. In either case, Marshall will provide project supervision.

The Micon report (Appendix A) presents estimates of the pre-production capital expenditures at Restigouche, on the assumption that Marshall will develop the project with its own personnel. The total estimated capital cost for an open-pit mine at Restigouche capable of producing 750 tonnes per day of ore is approximately $13.3 million, broken down as follows:

Item	Capital Cost ($000's)
MINING FACILITIES	
Engineering	200
Pre-production stripping/bulk sampling	1,600
Mine Equipment	5,000
Buildings and Surface Facilities	1,600
Direct Capital Cost	8,400
Contingency (12%)	1,000
Working Capital (3 months)	1,800
SUBTOTAL - MINING FACILITIES	11,200
WASTE MANAGEMENT FACILITIES	
Engineering	120
Ditches, Ponds, Pads	300
Treatment Plant	1,480
Contingency (12%)	230
SUBTOTAL - WASTE MANAGEMENT	2,130
TOTAL COST OF DEVELOPMENT	13,330

3.5.2 Operation and Maintenance Costs

Micon also estimated the operating costs of an open-pit mining operation at Restigouche, and has given these as $26.95 per tonne. This has been modified to include additional waste management and is broken down as follows:

Item	Operating Cost ($/tonne)
Drilling	1.35
Blasting	2.75
Loading	2.00
Mine Haulage	4.90
Direct Mining Cost	11.00
Haulage to Concentrator	5.40
Site Services (incl. Maintenance)	6.50
Environmental Aspects	0.75
Administration	3.30
Additional Waste Management	0.47
TOTAL OPERATING COST	27.42

Based upon the mining of 262,500 tonnes of ore per year, the annual operating and maintenance costs at Restigouche will be approximately $7.2 million.

3.5.3 Reclamation Costs

Upon the cessation of operations at the Restigouche site the reclamation plan calls for the potentially acid generating waste rock that is in the sulphide waste pile to be returned to the worked-out pit. On the preliminary assumptions that approximately 0.541 million tonnes of the waste removed from the pit may be potentially acid generating and that to return this material to the pit will cost about $2/tonne, a total cost of $1.08 million could be incurred for acid waste returned to the pit. It is estimated that additional reclamation activities described in Section 3.4 will cost approximately $500,000.

In summary, the total costs estimated to complete a walk-away reclamation plan at Restigouche are of the order of $1.6 million. This assumes worst-case maxima for both acid generating waste rock and the site reclamation.

3.5.4 Manpower Requirements

3.5.4.1 Construction

The proposed Restigouche open-pit mining operation does not have a distinct construction period, in that there is little in the way of buildings to erect or infrastructure to install. The operations crew will be involved in all of the set-up tasks, and manpower employed at the site will increase, over a 2-3 month period, to the full operational complement. Marshall has not, therefore, estimated the rapidly evolving manpower requirements for this phase.

3.5.4.2 Operation

Marshall's preliminary estimate for the manpower required to operate the Restigouche mine and ore haulage systems totals 55, 36 on day shift and 19 on the afternoon and night shifts. These are apportioned approximately as shown in Table 3-6.

TABLE 3-6

Estimated Manpower Requirements for Operation

	Day	Afternoon	Night	Total
Technical Staff & Office	9	-	-	9
Shop & Services	9	4	-	13
Mine (includes haulage to Caribou)	18	12	3	33
TOTALS	36	16	3	55

4.0 BIOPHYSICAL SETTING

The biophysical setting is presented here to allow assessment of the impact of the proposed mine on the environment. The major components of this setting are the terrestrial and aquatic environments.

4.1 Terrestrial Environment

Description of the terrestrial environment includes consideration of land uses in the vicinity of the proposed mine site and haulage road, geology, and hydrogeology. The description has been compiled from available information, discussions with appropriate resource managers, and detailed site investigations which were undertaken during 1988 and 1989. This section of the report considers the existing terrestrial environment onto which the mine development would be superimposed.

4.1.1 Description of Mine Site Area

The Restigouche deposit is located in the Central Highlands climatic region of New Brunswick. In general, this area experiences relatively shorter and cooler summers, and longer and colder winters than the remainder of the Province. The mean monthly temperatures vary from approximately -14°C in January to approximately 17°C in July. The maximum annual precipitation is approximately 1500 mm with a mean of approximately 1030 mm. The annual runoff for this region is approximately 610 mm.

The area between the deposit and Highway 180 is criss-crossed with numerous trails due to previous logging and exploration activities. The area near the deposit has been partially cleared due to exploration activities.

Tree cover at the Restigouche site is typical of the uplands forest component of the Acadia Forest Region. Discussions with the local DNRE office confirmed that the valley slopes along the north side of Charlotte Brook, near the site, were logged approximately 30 years ago. The valley slopes along the south side of the brook, near the Restigouche site, do not appear to have been logged recently.

The regenerating forest on the north side of Charlotte Brook consists primarily of trembling aspen, white birch, pin cherry, young balsam fir, spruce and white pine. The valley slopes along the south side of the brook consist primarily of mature balsam fir and spruce. The valley floor consists of alders and, in drier areas, balsam fir. Abandoned and drained beaver ponds at the Restigouche site are covered by grasses and alders. Discussions with personnel from the DNRE, the University of New Brunswick, and the New Brunswick Museum identified no unique forms of flora or fauna that would be at risk by development in this area.

Most species of wildlife native to north central New Brunswick can be expected to frequent the area during at least part of the year. Numerous tracks of deer and moose have been observed during site visits. Discussions with the local DNRE office indicate that the Restigouche site is not in close proximity to critical winter habitat for deer or moose. The nearest deer wintering area (known as Simpson's Field) is located along Simpson's Brook approximately two kilometres to the northwest of the site. The approximate location of the deer wintering area has been determined from 1986 - 1988 ground-survey information (G. Godin, DNRE, personal communication, 1989) and is shown in Figure 4-1.

4.1.2 Description of Haulage Road Area

The forest along the existing site access road appears to be regenerating from old (25-30 years) clearcut areas (as evidenced by decaying stumps, old logging roads and the small size of trees present). The forest in this area is mixed, composed of spruce, balsam fir, trembling aspen, white birch and red maple. In wetter areas white cedar and speckled alder occur. During the course of the field investigation tracks of deer, moose and bear were noted.

4.1.3 Land Uses

Numerous land uses of the terrestrial environment have been identified. The position of these relative to the proposed minesite is illustrated in Figure 4-1.

4.1.3.1 Timber Leases

The proposed development is located on Crown land within an area known as the Upsalquitch Licence. The provincial government has leased the pulpwood harvesting

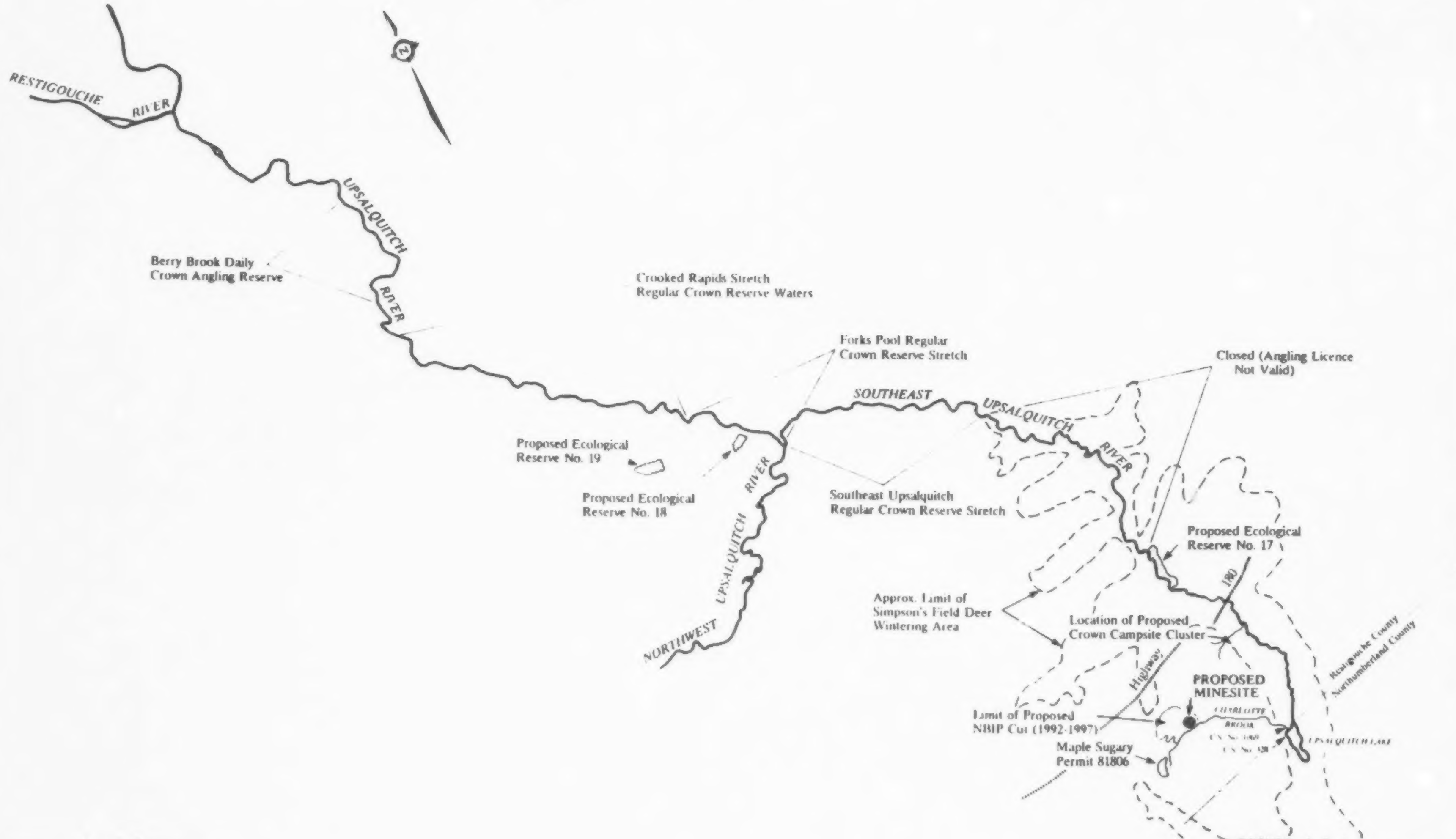

RESTIGOUCHE RIVER
UPSALQUITCH RIVER
Berry Brook Daily Crown Angling Reserve
Crooked Rapids Stretch Regular Crown Reserve Waters
Forks Pool Regular Crown Reserve Stretch
SOUTHEAST UPSALQUITCH RIVER
Closed (Angling Licence Not Valid)
Proposed Ecological Reserve No. 19
Proposed Ecological Reserve No. 18
NORTHWEST UPSALQUITCH RIVER
Southeast Upsalquitch Regular Crown Reserve Stretch
Proposed Ecological Reserve No. 17
180
Approx. Limit of Simpson's Field Deer Wintering Area
Location of Proposed Crown Campsite Cluster
Highway
Restigouche County
Northumberland County
PROPOSED MINESITE
CHARLOTTE BROOK
Limit of Proposed NBIP Cut (1992-1997)
Maple Sugary Permit 81806
UPSALQUITCH LAKE

FIGURE 4-1
LOCATON OF SPECIFIC LAND USES
AND COMPONENTS OF AQUATIC ENVIRONMENT

rights of this area to the New Brunswick International Paper Company (NBIP). Other timber products (saw logs, veneer, etc.) may be harvested by sub-licensees within the boundaries of this licence. Cutting plans have been filed by NBIP for an area to be cut during the period 1992-1997 in the vicinity of the proposed development (V. Mercer, DNRE, personal communication, 1989). This area is shown in Figure 4-1.

4.1.3.2 Hunting

The Upsalquitch drainage area is a popular hunting area, as are much of the remote areas in this part of the province. Redmond (DNRE, personal communication, 1989) suggests that hunters travel nearly all accessible forest roads during the fall months in pursuit of various species of game animals. The area of the proposed minesite is known to be frequented by hunters.

All species of game animals native to New Brunswick may be found in and around the Upsalquitch watershed. Moose, for example, are harvested by a limited number of resident hunters each fall. A review of the hunting statistics for 1987 shows that 125 moose were registered in Restigouche county. This represents about 7 percent of the total provincial harvest for that year. Using the hunter success ratio of 35 percent for that year, it may be assumed that approximately 360 hunters hunted moose in this county during 1987's three-day season.

White-tailed deer are the most popular big-game animal in the province. In 1987, for example, more than 100,000 hunters bought licenses. In the parish of Balmoral (the location of the Restigouche deposit), approximately 60-225 deer are harvested annually (fewer deer have been harvested in the past two seasons due to a reduced hunting season and the introduction of bucks-only regulation). Approximately 200 to 900 deer hunters hunt in this parish each fall.

Hunting of black bears appears to be a growing sport in the province. In 1987, 5365 hunters (mostly non-resident) harvested 976 bears. Of this total, 64 bears (6 percent) were harvested in Restigouche county (approximately 320 hunters).

In addition to big game hunting, almost 5000 small game hunting licenses were issued in Region 1 (Restigouche and Gloucester counties) in 1988. It should be noted that a deer license is also valid for small game hunting. The primary small game species include: ruffed grouse, spruce grouse, rabbits, and varmints (crows, ground hogs, cormorants, etc.).

In addition to the above, a number of general hunting licences for year round varmint control and federal migratory game birds permits (for hunting ducks, geese and woodcock) are also issued. These figures support the fact that hunting is a popular and widespread activity in this area of New Brunswick.

4.1.3.3 Trapping

Approximately 200 trappers were registered in Restigouche county in 1988. Discussions with local DNRE personnel confirmed that trapping of fur bearers is conducted throughout the Upsalquitch watershed area of the county. Godin (DNRE, personal communication, 1989), suggests that the area along Charlotte Brook is only lightly trapped (if at all). The area around the Portage Lakes, several kilometres to the west of the proposed development, is thought to attract more trapping activity.

4.1.3.4 Campsite Leases

There are a number of Crown campsite leases scattered throughout the Southeast Upsalquitch drainage area. These properties consist of one acre parcels of Crown land that are leased to companies or individuals for an annual fee ($150/year). Those properties closest to the location of the proposed minesite include two sites at Upsalquitch Lake (see Figure 4-1). One of these properties (No. 1069, leased to John Goulette) is on Charlotte Brook. The other property (No. 328, leased to NBIP) is on the lake shore. These camp leases are approximately 4 km from the site. Also, a cluster development of eight new campsites has been approved for an area near the access road to Upsalquitch Lake, approximately 1.5 km in from Highway 180. Currently there are restrictions for additional campsite development on the shores of Upsalquitch Lake (as with most lakes in the province). Discussions with DNRE have revealed that there are plans to construct a 10 unit picnic/camping area on the shores of Upsalquitch Lake.

4.1.3.5 Sugarbush Leases

There is some potential for maple sap collection in the area. An area approximately 2 km to the southwest of the proposed minesite (see Figure 4-1) has been leased for sap production (Permit No. 81806, leased to N. Arseneault for 2600 taps).

However, this lease was forfeited in the past year in favour of another site near Bathurst. It should be noted that the area of the proposed minesite has few large maple trees and therefore has little (if any) current potential for maple industry development.

4.1.3.6 Ecological Reserves

There are three proposed ecological reserves within the Upsalquitch drainage area (see Figure 4-1). All three of these areas have been selected to represent specific forest ecosystems typical of the forests in this area of the province. There are no existing or proposed ecological reserves in the immediate vicinity of the proposed minesite. Of the three proposed ecological reserves identified above, the nearest to the proposed development (No. 17) is located adjacent to the Southeast Upsalquitch River in the area known as the Southeast Gorge, more than 6 km away.

4.1.3.7 Fiddlehead Harvesting

Fiddleheads, the emerging spring shoots of the ostrich fern, are a very popular native food item that is gathered along stream valleys in the spring by commercial as well as domestic harvesters. The stream valley of Charlotte Brook is thought to be an insignificant site for fiddlehead harvesting (G. Godin, DNRE, personal communication, 1989).

4.1.3.8 Non-Consumptive Recreational Use

The general area of Upsalquitch Lake receives considerable public use for the purposes of touring, hiking and camping due to the close proximity to Mount Carleton

Provincial Park, and the relatively good access provided by Highway 180. No statistics are available to indicate the level of recreation in the area, but it is believed that areas adjacent to waterbodies (lakes, rivers) in this area generally receive "high" recreational use. The specific site of the proposed development is expected to experience "low" levels of recreational use (M. Fitton, DNRE, personal communication, 1989). The reasons for its low recreational importance are the remoteness of the site and its non-unique setting with respect to the surrounding area.

4.1.3.9 Heritage Resources

The Upsalquitch River has been included in a river systems planning study for selected rivers in New Brunswick. The purpose of this study is to evaluate selected rivers to determine their potential as provincially significant heritage resources and for consideration for nomination to the Canadian Heritage Rivers System. The study is currently under way, and it will be several months before the results are available.

With respect to human heritage, the Upsalquitch River has little known value. There are no recorded archaeological sites and sites of more recent human settlement are based around the lumbering industry in the 1800's (local sawmills or some other form of small water powered industry). However, several historical portages between the Upsalquitch River system and other waterways in the area are known. Generally, little is known about these routes. For the most part they are considered to be long and difficult portages and likely received limited use and therefore are of minor importance in comparison to other historical portages in the province.

4.1.4 Geology and Hydrogeology

4.1.4.1 Surficial Geology

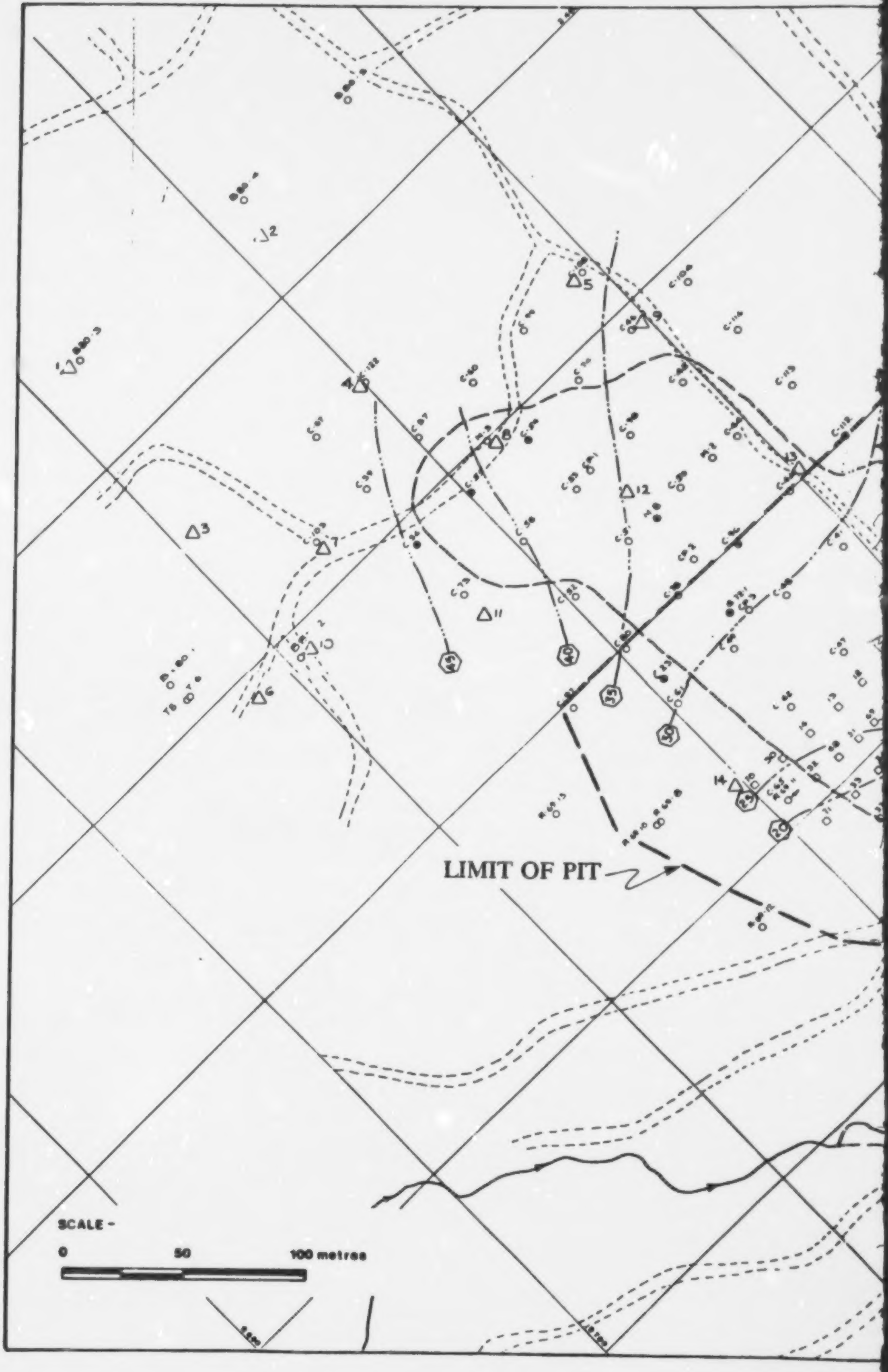
The area between Upsalquitch Lake and Second Portage Lake is blanketed with a veneer of stony till which is typically less than 0.5 metres thick, according to existing mapping (Rampton et al., 1984). The actual depth to bedrock in the mine area varied from zero to 4.11 metres on the basis of 24 test pits distributed as shown in Figure 4-2. The mean depth to rock was 0.88 metres.

Character of the Overburden

Twenty four test pits were dug for this project using a track-mounted excavator. The detailed logs of these test pits, and the results of laboratory testing carried out on the recovered soil samples are included in Appendix D.

A thin layer of silty sand and gravel occurs immediately below the topsoil cover. The combined thickness of these surficial sands and the organics is typically 0.25 m.

At one third of the test pit locations, the surficial layer rests directly on bedrock. Elsewhere, it is underlain by either ablation glacial till or by more clayey, basal glacial till. Only at one test pit location (TP 3) were both types of till present. Bedrock occurs immediately below the tills. The thickness of the various overburden deposits encountered at each test pit location are summarized in Table 4-1.



LIMIT OF PIT
SCALE -
0
50
100 metres
3
5
6
7
8
9
10
11
12
14
45
40
35
30
25
20

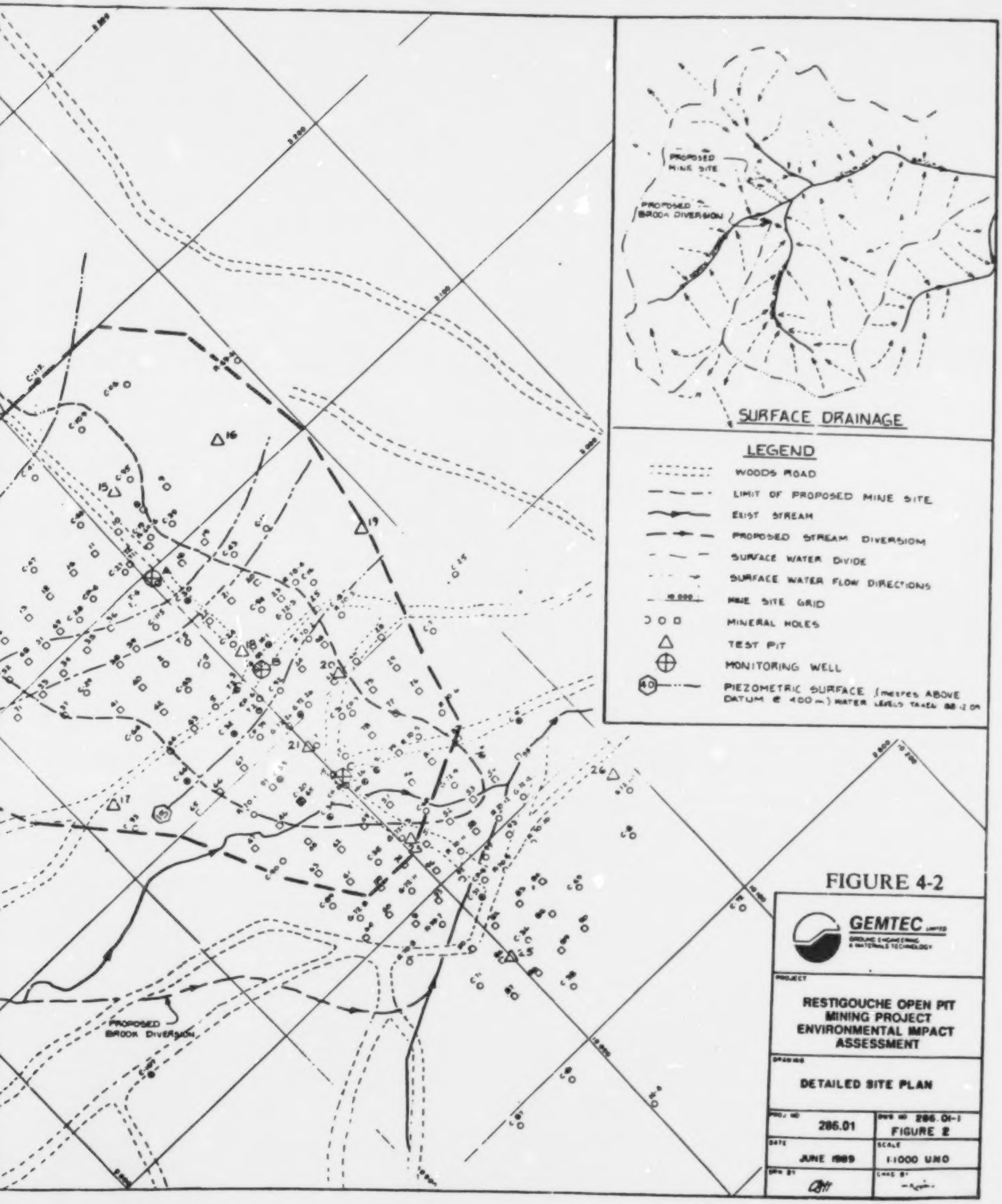

SURFACE DRAINAGE
PROPOSED MINE SITE
PROPOSED BROOK DIVERSION
LEGEND
WOODS ROAD
LIMIT OF PROPOSED MINE SITE
EXIST STREAM
PROPOSED STREAM DIVERSIOM
SURFACE WATER DIVIDE
SURFACE WATER FLOW DIRECTIONS
10 000
MINE SITE GRID
MINERAL HOLES
TEST PIT
MONITORING WELL
40
PIEZOMETRIC SURFACE (metres ABOVE DATUM @ 400 m) WATER LEVELS TAKEN 88-12-09
15
16
17
18
19
20
21
25
26
PROPOSED BROOK DIVERSION

FIGURE 4-2

GEMTEC LIMITED
GROUND ENGINEERING & MATERIALS TECHNOLOGY

PROJECT
RESTIGOUCHE OPEN PIT MINING PROJECT ENVIRONMENTAL IMPACT ASSESSMENT

DRAWING
DETAILED SITE PLAN

PROJ. NO 286.01	DWG NO 286.01-1 FIGURE 2
DATE JUNE 1989	SCALE 1:1000 UNO
DRN BY CJH	CHKD BY

TABLE 4-1

Summary of Test Pit Data

	THICKNESS (m)				DEPTHS (m)	
			Glacial Till			
Test Pit No.	Topsoil, Surficial Gravel	Miscellaneous	Ablation	Basal	Rock	Test Pit
1	0.22		-	0.39	0.61	2.59
2	0.15		0.15	-	0.30	0.61
3	0.22		1.00	0.76	1.98	1.98
4	0.21		-	0.40	0.61	0.79
5	0.10		0.20	-	0.30	0.91
6	0.31		-	3.35	3.66	3.66
7	0.31		-	-	0.31	0.91
8	0.24		-	-	0.24	0.76
9	0.37		-	-	0.37	0.79
10	0.25		-	0.36	0.61	0.91
11	0.61		-	-	0.61	0.91
12	0.27		0.34	-	0.61	0.76
13	0.30		-	-	0.30	0.91
14	0.25		-	0.66	0.91	0.91
15	0.25		-	-	0.25	0.91
16	0.25		0.66	-	0.91	1.52
17	0.22		0.26	-	0.48	1.06
18	0.22	3.43*	0.46	-	4.11	4.72
19	0.30	-	0.43	-	0.73	3.96
20	-	-	-	-	-	2.74
21	-	-	-	-	-	0.61
23	0.45	-	-	0.46	0.91	1.21
25		1.1**	-	-	1.10	2.53
26	0.25	-	-	0.96	1.21	2.59

* Silty fine to medium sand

** Fill

The ablation material referred to comprises sand and gravel with numerous cobbles and occasional boulders. The silt content is typically 10 to 20 percent. The natural moisture content of these soils varied from 20 to 34 percent and averaged 28 percent. Excluding the surficial gravels with organics, some of which may also be of ablation origin, these sands and gravels were encountered at eight of the twenty four test pit locations. Where present, the deposit thickness varied from 0.15 to 0.66 metres and averaged 0.44 metres.

More clayey sands and gravels containing cobbles and boulders were also encountered at eight test pit locations. This type of deposit is a basal glacial till and typically comprises 10 to 20 percent clay sizes and 20 to 40 percent finer than the 0.08 mm sieve size. The natural moisture content varied from 12 to 30 percent and averaged 19 percent. Where present, the deposit thickness varied from 0.36 to 3.35 metres and averaged 0.92 metres.

Bedrock was encountered at each test pit at an average depth of 0.88 metres. Depth to rock exceeded two metres in only three places; these being at test pits 3, 6 and 18. At TP 18 where the overburden was thickest (4.11 metres), the soil comprised very moist silty fine to medium sand, a deposit not encountered elsewhere. The volcanic bedrock as exposed in the test pitting operations was generally well jointed and weak to moderately strong. In several holes, particularly at TP 19, 20, 25 and 26 the rock was completely weathered to the consistency of a stiff clay which had a natural moisture content in excess of 15 percent.

The hydraulic conductivities, K, of recompacted samples of representative glacial tills were determined by means of a back-pressure parameter. K values of $5x10^{-6}$ cm/s and $1x10^{-7}$ cm/s were obtained for samples of the ablation and basal till, respectively. In each case, the samples were compacted at or close to the Maximum Dry Density as determined by ASTM D-698-A. Detailed results are given in Table 4-2. The field hydraulic conductivities would be considerably higher than those applicable to the compacted state.

TABLE 4-2

Hydraulic Conductivity Test Results - Overburden

Sample Location	Type	Material finer than 0.08 mm size, %	Maximum Dry Density t/m³	Optimum Moisture Content %	Saturated Hydraulic Conductivity K, cm/s
TP 6 Samples 1 & 2	Basal Till	34.4*	1.76	19	$1x10^{-7}$
TP 5 Sample 1	Ablation Till	16.7	1.40	30	$5x10^{-6}$

* Approximate (mean of TP 6 #1 and TP 6 #2)

4.1.4.2 Bedrock Geology

Published geological mapping (Fyffe, 1971; 1973) indicates that the general area of development lies within an Ordovician rock unit comprising quartz feldspar augen schists with a north-south striking cleavage which dips to the west at 30° to 50°. From the detailed mineral exploration drilling program, it is known that at the proposed mine site a sequence of rhyodacite and rhyolite tuffs and flows occur above and below the massive sulphides.

Diabase dykes cross the area. The massive sulphides occur within a 10-50 metre thick zone which outcrops at the surface by Charlotte Brook, dips west at between 30° and 50° and plunges gently northwards at 25°. Previous workers have suggested that the Restigouche deposit is cut off by a major fault down-dip to the north, beyond the limit of the open-pit reserves. However, careful re-interpretation of the data by Marshall has indicated that the northern end of the deposit is most probably marked by a simple stratigraphic thinning of the massive sulphides.

An interpreted cross section through the minesite is shown in Figure 4-3, based on geological data from selected mineral drill holes. The section passes through water wells A, B and C, which were drilled as part of this study.

4.1.4.3 Hydrogeology

Regional Hydrogeology

The region is characterized by pronounced local relief and as such, the shallow local system of groundwater flow is likely to be dominant. The proposed mine site is located close to the drainage divide between the area's two largest river systems: the Upsalquitch to the north and the Nepisiguit to the south. Groundwater which is not intercepted by the local flow systems would therefore move to great depth before eventually migrating to the north or south.

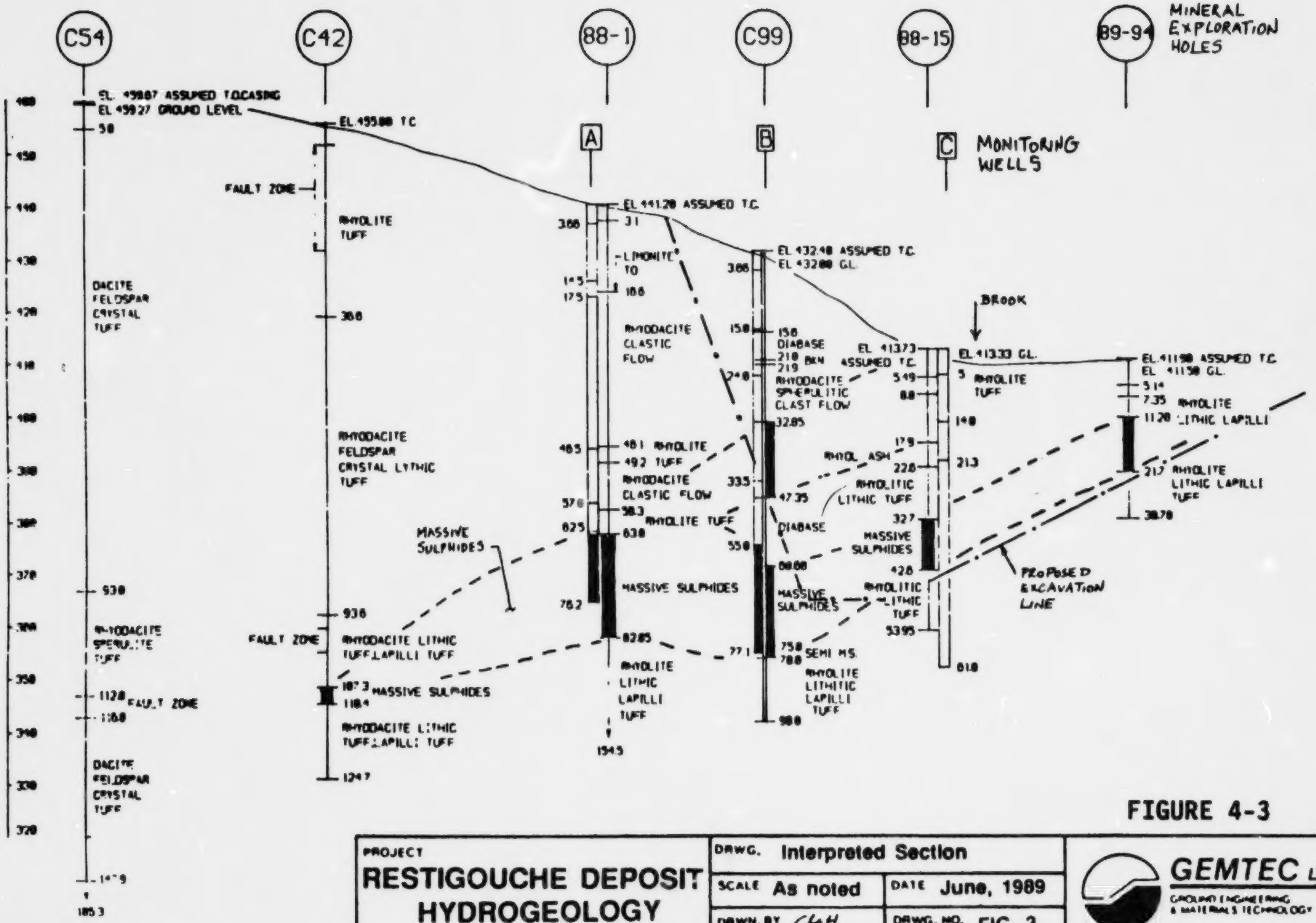

C54
C42
88-1
C99
88-15
89-94
MINERAL EXPLORATION HOLES
A
B
C
MONITORING WELLS
480
450
440
430
420
410
400
390
380
370
360
350
340
330
320
EL. 49887 ASSUMED T.O.CASING
EL 49927 GROUND LEVEL
50
DACITE FELDSPAR CRYSTAL TUFF
930
RHYODACITE SPERULITE TUFF
1120
FAULT ZONE
1160
DACITE FELDSPAR CRYSTAL TUFF
1479
1853
EL.49500 T.C
FAULT ZONE
RHYOLITE TUFF
300
RHYODACITE FELDSPAR CRYSTAL LYTHIC TUFF
936
FAULT ZONE
RHYODACITE LITHIC TUFF/LAPILLI TUFF
1073
MASSIVE SULPHIDES
1184
RHYODACITE LITHIC TUFF/LAPILLI TUFF
1247
MASSIVE SULPHIDES
EL 441.20 ASSUMED T.C.
3.00
3.1
LIMONITE TO
14.5
17.5
10.0
RHYODACITE CLASTIC FLOW
48.5
48.1 RHYOLITE
49.2 TUFF
RHYODACITE CLASTIC FLOW
57.0
58.3
RHYOLITE TUFF
62.5
63.0
MASSIVE SULPHIDES
76.2
82.85
RHYOLITE LITHIC LAPILLI TUFF
154.5
EL 432.40 ASSUMED T.C.
EL 432.00 GL.
3.00
15.0
15.0
DIABASE
21.0
BKN
21.9
24.0
RHYODACITE SPHERULITIC CLAST FLOW
32.85
33.5
47.35
DIABASE
55.0
60.00
MASSIVE SULPHIDES
77.1
75.0
SEMI MS.
78.0
RHYOLITE LITHITIC LAPILLI TUFF
90.0
BROOK
EL 413.73 ASSUMED T.C.
EL.413.33 GL.
5
RHYOLITE TUFF
5.49
8.0
14.0
17.9
RHYOL. ASH
21.3
22.0
RHYOLITIC LITHIC TUFF
32.7
MASSIVE SULPHIDES
42.0
RHYOLITIC LITHIC TUFF
53.95
61.0
EL.411.90 ASSUMED T.C.
EL 411.50 GL.
5.14
7.35
RHYOLITE LITHIC LAPILLI
11.20
21.7
RHYOLITE LITHIC LAPILLI TUFF
38.70
PROPOSED EXCAVATION LINE

FIGURE 4-3

PROJECT **RESTIGOUCHE DEPOSIT HYDROGEOLOGY**	DRWG. Interpreted Section		**GEMTEC LIMITED** GROUND ENGINEERING & MATERIALS TECHNOLOGY
	SCALE As noted	DATE June, 1989	
	DRWN. BY CGH	DRWG. NO. FIG. 3	

Local Hydrogeology

The pronounced relief of this part of the New Brunswick Highlands is consistent with the development of relatively shallow, local systems of groundwater flow. As such, groundwater flow directions will be very much influenced by the surface topography. Piezometric data (discussed later in this section) show that most of the mine development is in a recharge area characterized by significant depths to the water table. Discharge conditions occur by Charlotte Brook.

Small scale variations in the bedrock geology will also affect groundwater movement. In this context, the presence of diabase dykes within the massive sulphides is worthy of comment. The north-central portion of the Restigouche massive sulphide body is cut by several northwest-southeast trending diabase dykes, all very closely spaced en echelon and most probably parts of a single dyke episode. As shown in Figure 4-4, which is a level plan through the deposit at the 382.5 m elevation, the dykes thicken and thin and pinch out irregularly across the deposit. Maximum thickness of any one part of a dyke is approximately 5 m, and the dyke trend is sub-parallel to that of Charlotte Brook.

In drill cores, the dykes exhibit variable contacts with the country rock, as is typical of diabase dyke intrusions, and although the contacts may be fractured and altered for some 10-15 cm in from the edges they are most commonly tight and undisturbed. The

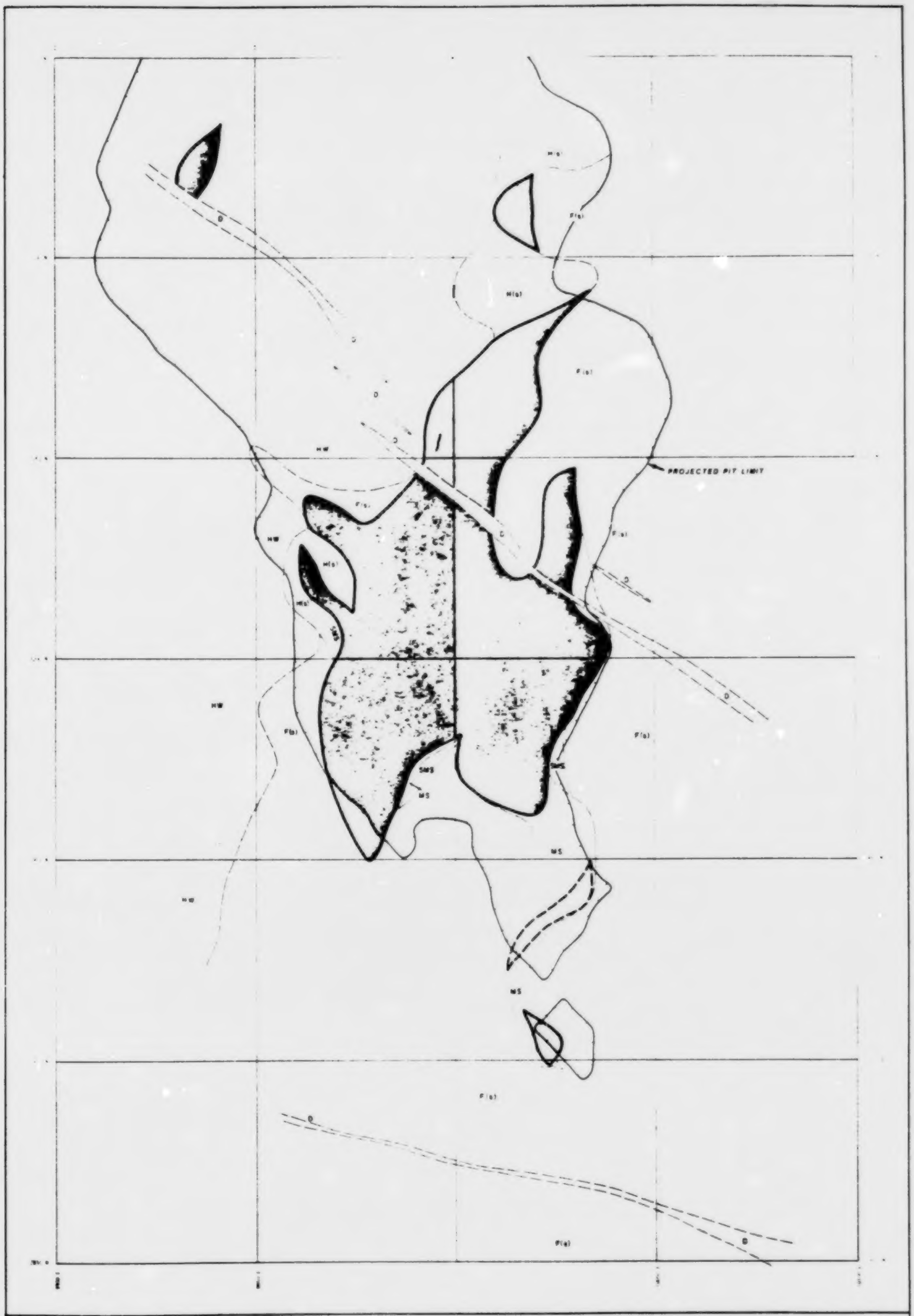

H(s)
F(s)
H(s)
D
D
D
HW
PROJECTED PIT LIMIT
F(s)
HW
H(s)
H(s)
D
F(s)
D
HW
F(b)
F(s)
SMS
MS
SMS
MS
HW
MS
F(s)
D
F(s)
D
LEGEND
O Overburden
HW Hanging wall
H(s) Hanging wall
Fw Footwall
Ms Massive
SMS Semi Massive
D Diabase Dyke
SCALE 1:500
METRES
FEET

FIGURE 4-4

Neil D.S. Westell & Associates Ltd.

MARSHALL MINERALS CORPORATION

RESTIGOUCHE DEPOSIT
Restigouche Co., New Brunswick
N.T.S. 21/O 7&10 V148A

GEOLOGICAL LEVEL PLAN
382.5m ELEVATION

Drawn by	[illegible]	Date	NOV 1989
Approved		Scale	[illegible]

dykes often have tension or cooling fractures sub-parallel to their margins, but typically these would not be hydraulically continuous for distances in excess of 1 or 2 m. As would be expected, tension or cooling fractures are less common in the centres of the dykes. One of the water wells test-pumped for this study (hole B, Figure 4-3) encountered substantial sections of diabase, yet its transmissivity (see Table 4-4) was intermediate between those for holes A and C. Therefore, there is no reason to believe that the diabase dykes cutting the Restigouche massive sulphides will act as aquifers or hydraulic drains from the pit.

Hydraulic Conductivity

The hydraulic conductivity of bedrock units such as this is generally governed by fracture porosity rather than by the porosity of the intact rock. Highly fractured bedrock would be more transmissive than less fractured rock. For this reason, cores from sections of several of the "mineral" drill holes were evaluated from the fracture-spacing perspective. The results of the analysis are tabulated in Appendix E. Fracture spacing is expressed as RQD (Rock Quality Designation); this being, for each core run, the percentage of the core recovered in sticks longer than 100 mm. Efforts were made to ignore those fractures which had been produced during the drilling and/or subsequent handling processes, but the assessment was not a rigorous one.

Fracture spacing generally increased with depth, the RQD usually exceeding 40 percent below depths shown in Table 4-3.

TABLE 4-3

Fracture Spacing Data - Selected Boreholes

Borehole	Weighted Avg. RQD %	REC %	Depth Below Which RQD Generally Exceeds 40%	Adjacent Water Well
88-1	73	100	16 m	A
88-15	55	90	17 m	C
88-44	38	100	27 m	
88-99	59	97	18 m	B

Of the examined cores, overall rock quality was greatest in hole 88-1, was intermediate in holes 88-15 and 88-99, and was least in hole 88-44. Three 150 mm diameter wells labelled A, B and C were drilled in the proposed open-pit area. Well locations and depths are shown in Figures 4-2 and 4-3, respectively. Logs of each hole, based on chip samples recovered at one to five metre intervals, are included in Appendix F.

Each of the drilled wells was test-pumped for evaluation of hydrogeologic parameters. The results are summarized in Table 4-4 below and given in detail in Appendix G.

TABLE 4-4

Results of Pump Testing

Well No	Transmissivity igpd/ft	cm²/s	Hydraulic Conductivity K, cm/s
A	350	0.60	7.9×10^{-5}
B	450	0.77	1.0×10^{-4}
C	1000	1.726	2.8×10^{-4}
		Average	1.5×10^{-4} cm/s

The lowest hydraulic conductivity, K, occurred in Test Well A drilled adjacent to mineral hole 88-1 where the degree of fracturing was relatively low. The highest K value occurred in Well C by Charlotte Brook, drilled near mineral hole 88-15 where the core was more broken. The storage terms varied from as high as 0.25 to less than 1×10^{-4} based on the response at the pumped wells and the observation holes, respectively.

The bedrock hydraulic conductivity can also be estimated by examining the slope of the water table/piezometric surface which has developed under ambient recharge conditions. In this case, the annual rate of recharge to the groundwater system is estimated to be 65 mm; this being approximately the base flow received by the three small northern streams for which data are available (Environment Canada, 1985). This flux of groundwater infiltration is moved from the recharge area to the discharge area by Charlotte Brook under piezometric conditions as revealed by the water levels in the exploratory holes. The depth to groundwater in these holes was typically 10 to 25 metres. The bedrock hydraulic conductivity required to reconcile the above recharge and piezometric data is approximately 4×10^{-5} cm/s which is lower than, but of the same order of magnitude as those values obtained from test pumping.

Piezometric Data

Water level information from selected mineral drill holes and from the three water wells, is given in Table 4-5 and in plan form in Figure 4-5. The depth to the water table/piezometric surface varied from in excess of 25 metres at exploratory hole M-2 to slightly above grade at mineral holes T6 and B80-3.

Contours of the piezometric surface and groundwater flow directions shown in Figure 4-5 are tentative only. The drill holes are very deep and the piezometric head registered by a water level in these holes is therefore an average value of head occurring within the explored depth. Recharge conditions apply over most of the area while groundwater is discharged to the surface system at Charlotte Brook.

Groundwater Chemistry

Water samples were recovered from each of the three drilled wells during test pumping, from two upgradient mineral drill holes which were overflowing, and from an upgradient spring. These samples were analyzed for major ions and the results are shown in Table 4-6.

TABLE 4-5

Water Levels in Exploratory Drill Holes - December 9, 1988 and April 20, 1989

Section Line	Drill Hole #	88/12/09 Elevation of Top of Casing, Metres	Depth of Hole Metres	To Water Below Casing Metres	Water Level Metres	89/04/20 To Water Below Casing Metres	Water Level Metres
3322	C-57	457.37	275.5	13.43	443.94	10.33	447.04
3322	C-60	460.33	271.3	20.85	439.48	17.60	442.73
3322	C-99	462.15	183.8	24.69	437.46	21.76	440.39
3392	C-54	459.27	186.2	21.45	437.82	18.17	441.10
3261	C-73	455.03	186.2	10.38	444.65	9.05	445.98
3261	B-80-7	457.63	239.0	19.08	438.55	17.01	440.62
3231	M-2	458.41	118.9	26.92	431.49	23.90	434.51
3200	C-42	455.8	124.7	24.87	430.93	21.84	433.96
3170	C-49	451.66	142.0	21.69	429.97	18.84	432.82
3170	C-116	450.11	99.7	>21.62	<428.49		
3139	C-62	446.72	121.9	16.95	429.77	14.24	432.48
3139	C-40	450.34	175.90	21.69	428.65		
3109	R-69-11	440.24	148.7	21.13	421.09	17.06	424.78
3093	88-1	440.8	154.5	12.22	428.58		
3063	88-2	436	87.5	17.2	418.8	14.75	421.25
3033	88-5	432.3	90.5	14.59	417.71	12.58	419.72
3033	88-3	432.62	94.5	15.49	417.13	13.60	419.02
3002	88-6	423.40	66.1	10.45	412.95	9.52	413.88
2957	88-7	416.31	60.4	3.36	412.95	2.45	413.86
2929	C-89	414.08	61.6	0.68	413.4		
2915	G-72-8	414.42	78.6	0.96	413.46	0.97	413.45
2972	88-15			0.25			

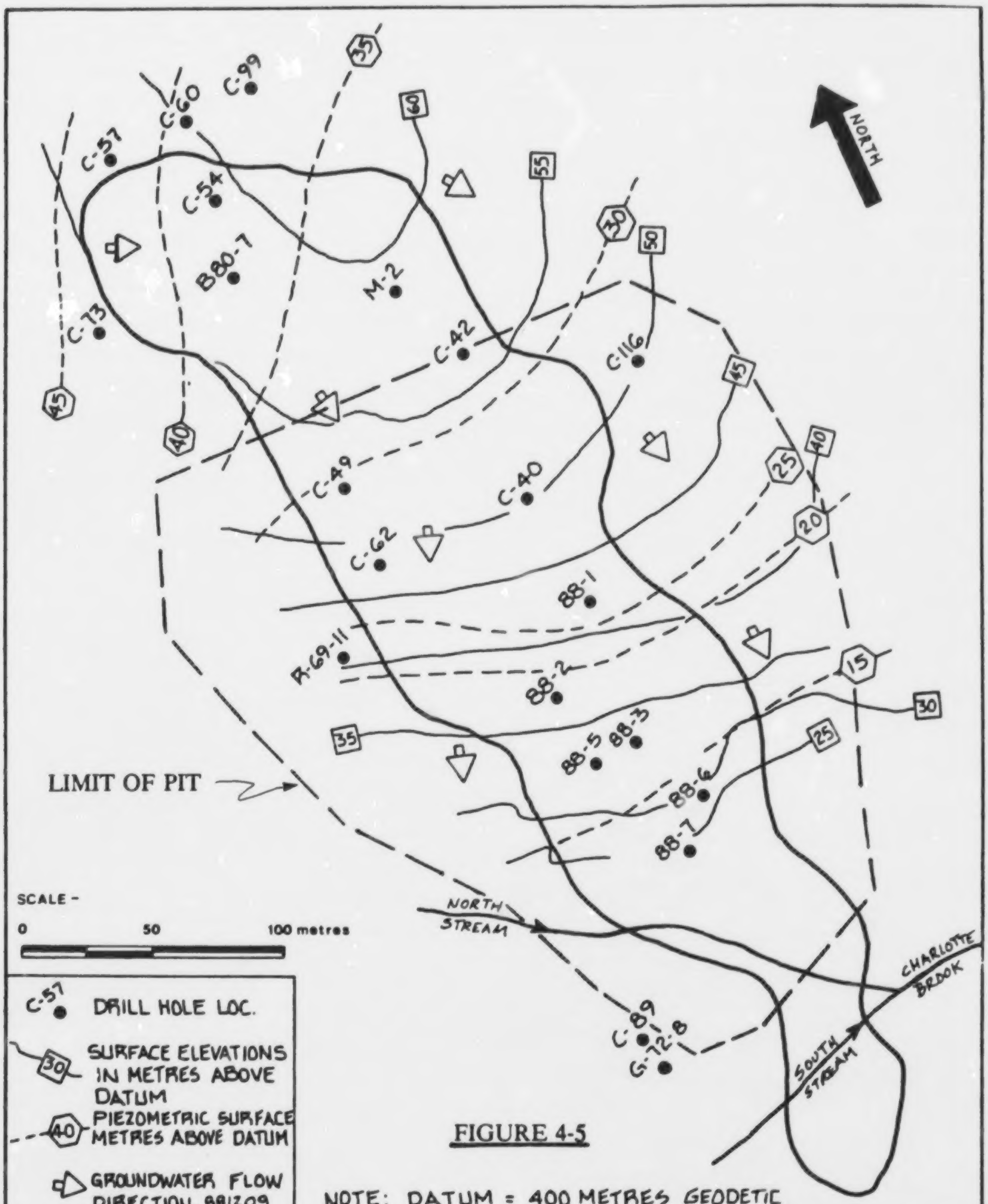

NORTH
C-99
C-60
C-57
C-54
B80-7
M-2
C-73
C-42
C-116
C-49
C-40
C-62
88-1
R-69-11
88-2
88-5
88-3
88-6
88-7
C-89
G-72-8
35
60
55
30
50
45
40
45
25
40
20
15
30
35
25
LIMIT OF PIT
NORTH STREAM
SOUTH STREAM
CHARLOTTE BROOK
SCALE -
0
50
100 metres
C-57 DRILL HOLE LOC.
30 SURFACE ELEVATIONS IN METRES ABOVE DATUM
40 PIEZOMETRIC SURFACE METRES ABOVE DATUM
GROUNDWATER FLOW DIRECTION, 88/209

FIGURE 4-5

NOTE: DATUM = 400 METRES GEODETIC

PROJECT RESTIGOUCHE DEPOSIT HYDROGEOLOGY	DRWG. PIEZOMETRIC SURFACE	GEMTEC LIMITED GROUND ENGINEERING & MATERIALS TECHNOLOGY
	SCALE 1:2000	DATE JUNE 1989
	DRAWN BY GBH	DRWG. NO. FIG. 4

TABLE 4-6

Water Chemistry - Samples Recovered May 2, 3 and 4, 1989
All Results Expressed in Mg/l

Sample No	Well A (After 4 hrs) pumping)	Well B	Well C	E*	F*	S*
Date Sampled	89 05 02	89 05 02	89 05 03	89 05 04	89 05 04	89 05 04
pH	7.71	8.36	7.47	7.13	7.14	6.30
Alkalinity (as CaCO3)	54.7	76.5	75.4	38.0	34.8	4.2
Sulfate	15.4	26.8	17.8	5.03	4.85	4.53
Ca	16.8	23.5	24.4	10.9	10.1	0.21
Mg	6.16	9.95	7.70	3.65	3.34	1.00
Extractable Metals:						
Al	<0.1	0.3	0.5	<0.1	<0.1	<0.1
As	<0.01	0.05	0.04	<0.01	<0.01	<0.01
Cu	0.02	0.02	0.01	<0.01	<0.01	<0.01
Fe	0.21	1.04	1.52	4.77	0.03	<0.02
Mn	0.06	0.12	0.39	0.04	<0.01	<0.01
Pb	0.04	0.80	0.16	<0.02	<0.02	<0.02
Zn	0.10	0.24	0.55	0.02	0.01	0.02

*E Upgradient artesian mineral drill hole T6
F Upgradient artesian mineral drill hole B80-3
S Spring by Ideal Drilling's camp site.

Water quality was similar at each of the newly drilled holes (A, B and C). The pH varied from 7.4 to 8.4 while the sulphate concentration varied from 15 to 27 mg/l. The water from holes A, B and C contain high levels of Fe, Pb and Zn, which is to be expected since they penetrate the sulphide ore body; the relatively high sulphate levels in the water from these holes tend to support this interpretation. The metals concentration at Well A decreased with pumping time; iron, for example falling from 0.85 mg/l at 10 minutes to 0.21 mg/l at 4 hours.

The sulphate levels and the pH of samples recovered from the upgradient locations E, F and S, were somewhat lower than those from the pumped wells and the samples were generally less mineralized. The high iron content of sample E may be attributable to alteration (rusting) of the steel casing, since there are no sulphides recorded in the original core log of that hole (T-6). This hole was, however, collared in oxidized and brecciated gabbro, and the iron may partly have been derived from that rock type.

4.2 Aquatic Environment

Preliminary assessment of information on the aquatic environment indicated that the data available was insufficient to characterize certain components. Therefore, detailed site investigations were undertaken during 1988 and 1989 to obtain sufficient background data to establish the pre-development environment.

Accordingly, six stations were established in the vicinity of the proposed mine site to monitor baseline surface water quality, fish populations and habitat characteristics, and benthic invertebrate populations. The data collected during this program were combined with existing information to compile a description of the aquatic environment.

Description of the aquatic environment includes consideration of water quality and sediment geochemistry of surface water resources, aquatic habitat, fisheries resources, and benthic invertebrates. The various components comprising the aquatic environment adjacent to and downstream of the proposed minesite are illustrated in Figure 4-1.

4.2.1 Surface Water Resources

Charlotte Brook is the major source of surface water near the Restigouche deposit. The brook, which divides into north and south branches upstream of the deposit, drains an area of approximately 15 km^2 at its outlet into Upsalquitch Lake. The area upstream of the deposit contains a drainage area of approximately 5.5 km^2. The brook is characterized by a steep gradient throughout its length (3 to 7%). The annual average runoff in this region of New Brunswick is approximately 600 mm (Acres, 1977). Long-term records for various stream gauging stations in the area (Nepisiguit, Eel and Bass Rivers) indicate that spring flows are approximately 4.5 times the mean annual runoff. Summer flows are approximately 0.5 times the mean annual runoff. Typical flows to be expected in Charlotte Brook on this basis are given in Table 4-7.

Upsalquitch Lake has a surface area of approximately 68 ha, a total volume of approximately 4 million m^3, and controls a drainage area of approximately 28 km^2 at its outlet into the Southeast Upsalquitch River. Thus Charlotte Brook, with a drainage area of approximately 15 km^2, is a major source of inflow of water into the lake.

The Southeast Upsalquitch River is joined by numerous tributaries along its length before its confluence with the Northwest Upsalquitch River, approximately 35 km downstream. From this point, the Upsalquitch River flows approximately 40 km to its confluence with the Restigouche River, 25 km upstream of Tide Head. The total drainage area of the Upsalquitch River system is approximately 2300 km^2.

TABLE 4-7

Nominal Flow Rates - Charlotte Brook

	At Restigouche Site	At Outlet to Upsalquitch Lake
drainage area (km^2)	5.5	15
mean annual flow (m^3/s)	0.1	0.3
mean spring flow (m^3/s)	0.5	1.4
mean summer flow (m^3/s)	0.05	0.15
7 day low flow - 10 year return period (m^3/s)	0.05	0.1
30 day low flow - 10 year return period (m^3/s)	0.1	0.4
90 day low flow - 10 year return period (m^3/s)	0.4	1.0

4.2.1.1 Water Quality

Water quality was monitored at the six sites established in the vicinity of the proposed mine site. The location of each station is shown in Figure 4-6 and is described below.

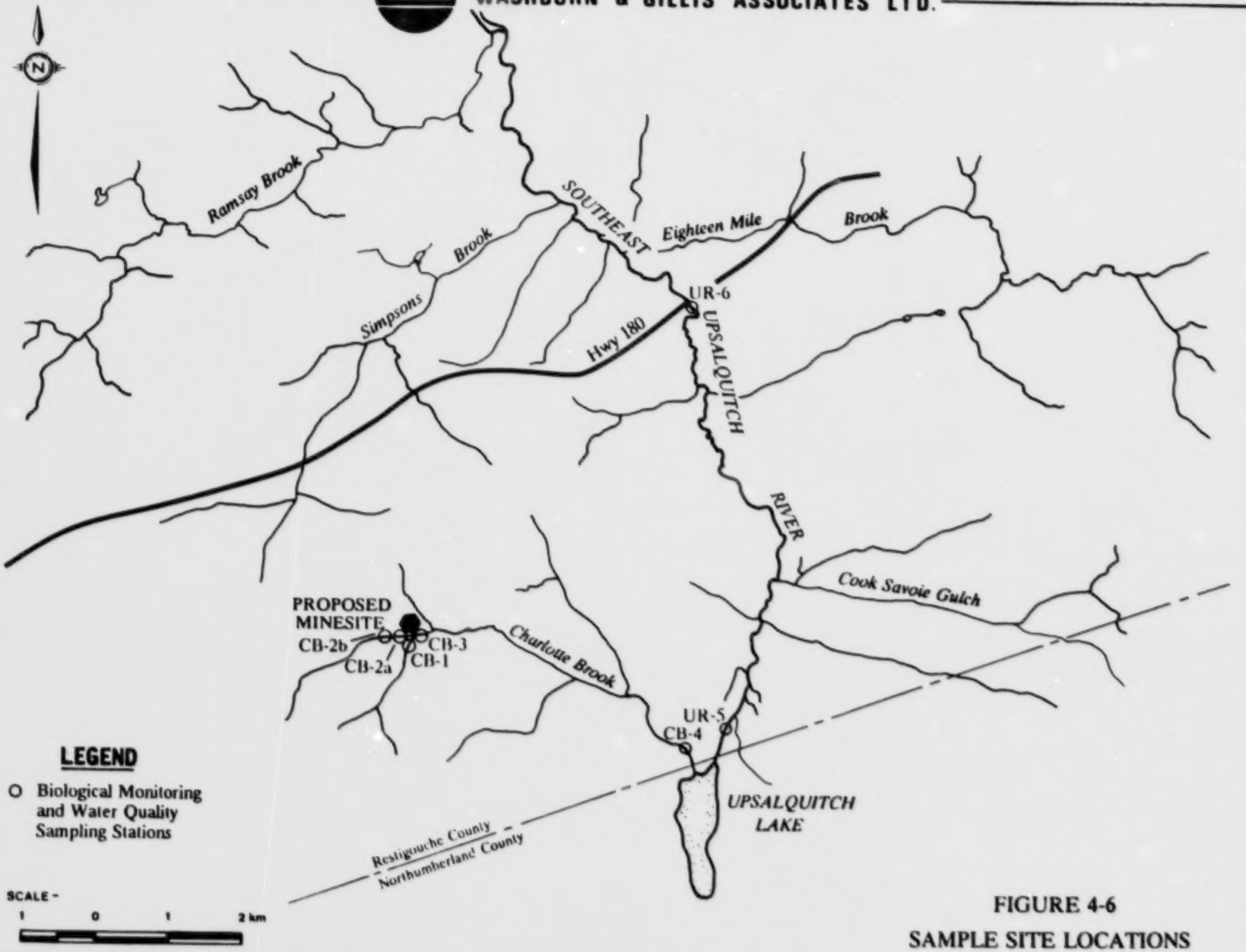

N
Ramsay Brook
Simpsons Brook
SOUTHEAST
UPSALQUITCH
RIVER
Eighteen Mile Brook
UR-6
Hwy 180
Cook Savoie Gulch
PROPOSED MINESITE
CB-2b
CB-2a
CB-3
CB-1
Charlotte Brook
UR-5
CB-4
UPSALQUITCH LAKE
Restigouche County
Northumberland County
LEGEND
○ Biological Monitoring and Water Quality Sampling Stations
SCALE -
1
0
1
2 km

FIGURE 4-6
SAMPLE SITE LOCATIONS

Station CB-1 and CB-2a

Station CB-1 is located on the south branch of Charlotte Brook and station CB-2a is located on the north branch of Charlotte Brook. Both sites are upstream of the proposed minesite and will provide data on background water quality conditions before and after site development and will allow comparison of data from stations downstream of the site to determine the effect of site operations.

Station CB-3

Station CB-3 is located on Charlotte Brook downstream of the site and the confluence of the north and south branches. This station will provide baseline conditions below the proposed discharge point for waters leaving the mine site.

Station CB-4

This station is located on Charlotte Brook just upstream of Upsalquitch Lake. Data collected at this location will be indicative of water quality in the lower Charlotte Brook watershed and of baseline conditions in the principal receptor stream for mine site discharges.

Station UR-5

This station is located on the Southeast Upsalquitch River just downstream of Upsalquitch Lake. Data from this station will provide baseline conditions for the quality of water flowing out of the lake.

Station UR-6

Station UR-6 is located on the Southeast Upsalquitch River at Highway 180. This is the furthest station from the proposed minesite and will provide data to establish baseline water quality at a distance downstream from the site.

Water quality data for sample locations in Charlotte Brook and the Southeast Upsalquitch River, near Upsalquitch Lake, are given in Appendix H and summarized in Table 4-8. The data indicate that the surface water is low in dissolved minerals content, "soft" due to the low concentrations of calcium and magnesium, and slightly alkaline. The waters contain at least traces of iron and manganese. The concentrations of other heavy metals, with the exception of zinc, at the sampling site in Charlotte Brook immediately downstream of the Restigouche deposit, are below or slightly above the specified detection limits.

4.2.1.2 Sediment Geochemistry

In addition to sampling water, sediment samples were collected at selected stations to develop baseline geochemical data. Stream sediment geochemical data are given in Appendix I for the Upsalquitch Lake watershed. The most recent data (collected in July 1988) are consistent with historical data. Elevated concentrations of heavy metals immediately downstream of the Restigouche deposit reflect the presence of the known sulphide mineral deposit.

TABLE 4-8

Summary - Surface Water Quality Data
Sampling Period September 1988, June, July, August 1989

	N. Branch Upstream (CB-2)	S. Branch Upstream (CB-1)	Charlotte Brook Downstream Deposit (CB-3)	Charlotte Brook at Upsalquitch L. (CB-4)	S.E. Upsalquitch at Upsalquitch L. (UR-5)	S.E. Upsalquitch at HW 180 (UR-6)
Colour (CU)	<5-7 (3)[a]	0.2-0.8 (3)	0.3-2.0 (3)	0.3-1.5 (3)	10-15 (3)	12-15 (3)
Turbidity (NTU)	0.4-1.4 (3)	<5-7 (3)	<5-10 (3)	<5-6 (3)	0.5-1.1 (3)	1.5-3.5 (3)
pH	7.53-7.92 (4)	7.48-7.64 (4)	7.54-7.76 (4)	7.54-7.76 (4)	7.01-7.26 (3)	7.41-7.45 (3)
Alkalinity (as $CaCO_3$)	33.5-39.2 (4)	15.9-18.6 (4)	26.0-31.2 (4)	20.6-24.1 (4)	12.3-13.1 (3)	16.2-20.4 (3)
Calcium	10.3-12.0 (4)	4.80-5.53 (4)	8.05-9.25 (4)	6.58-7.17 (4)	3.93-4.23 (3)	5.70-6.82 (3)
Magnesium	2.53-2.79 (4)	1.35-1.51 (4)	2.10-2.39 (4)	1.91-2.14 (4)	1.34-1.44 (3)	1.54-1.69 (3)
Iron	0.05-0.27 (4)	<0.002-0.02 (4)	0.06-0.58 (4)	0.02-0.15 (4)	0.06-0.14 (3)	0.20-0.30 (3)
Manganese	0.04-0.14 (3)	<0.01 (3)	0.03-0.10 (3)	0.01-0.05 (3)	0.01-0.03 (3)	0.02-0.02 (3)
Aluminum	<0.1 (4)	<0.1 (3)	<0.1 (3)	<0.1 (3)	<0.1 (3)	<0.1 (3)
Arsenic	<0.01 (3)	<0.01 (3)	<0.01 (3)	<0.01 (3)	<0.01 (3)	<0.01 (3)
Cadmium			<0.01 (3)			
Copper	<0.01 (4)	<0.01 (4)	<0.01 (4)	<0.01 (4)	<0.01 (3)	<0.03 (3)
Lead	<0.02 (4)	<0.02 (4)	<0.02 (4)	<0.02 (4)	<0.02 (3)	<0.02 (3)
Mercury			<0.001 (3)			
Zinc	<0.01-0.01 (4)	<0.01 (4)	0.02-0.05 (4)	<0.01 (4)	<0.01 (3)	<0.01 (3)

[a] - Number of samples; concentrations are mg/l.

4.2.2 Aquatic Habitat

Detailed information on the aquatic habitat of Charlotte Brook and the upper reaches of the Southeast Upsalquitch River was unavailable. Therefore, habitat evaluation was conducted during site visits to determine the presence of sensitive habitats in the potential area of influence. The habitat in surface waters in the vicinity of the proposed minesite is described below.

The habitat evaluation of Charlotte Brook was conducted on June 28, 1989. Charlotte Brook consists of two small branches at the proposed minesite. Adjacent to the proposed minesite the north branch largely consists of a series of old abandoned beaver ponds (shallow, wide waterbodies with deep layers of organic sediment). The stream channels connecting these ponds are approximately 1 to 1.5 m wide with an average depth of 20 cm. The poor condition of the dams, as well as the lack of freshly cut trees, suggest that the ponds in the vicinity of the minesite are not currently occupied by beavers. Alder and grasses occur at stream side in this area and provide some over head cover and shade. The stream sections connecting these small ponds have small areas where current velocity prevents the accumulation of organic matter, and the stream bottom consists of limited amounts of sand, gravel and rubble-sized rock. For a distance of approximately 80 m upstream of the confluence of the north and south branches, the stream is somewhat more free flowing with some exposed gravel and sand. There are small pools and an abundance of cover in the form of fallen trees and over-hanging vegetation with the stream being densely shaded with alders. The water was observed to be slightly coloured and the midday water temperature at the location of the proposed minesite was 17°C. Along the section of the north branch being considered for diversion brook trout spawning habitat appears to be very limited. The majority of this section consists largely of rearing and nursery habitat.

The south branch is slightly smaller than the north branch with a stream channel width of approximately 1 m, and an average depth of 10 cm. The south branch also has a steep gradient and is more free flowing, without the remnants of old beaver dams. The stream substrate consists predominantly of gravel and rubble-sized rock with few areas of organic deposits. Due to its small size, this stream is densely shaded by alders and other larger tree species. The south branch has clear running water and the mid-day water temperature was 12°C.

A small poorly-defined intermittent stream flows into Charlotte Brook approximately 250 m below the confluence of the north and south branches. This drainage channel is approximately 0.5 m wide, with substrate consisting of a varied mixture of gravel to boulder sized material originating from washouts during high runoff conditions. The channel is cluttered with much debris and is surrounded by a mixture of small hardwood and softwood species. The channel is very steep along much of its course and water flows only during periods of snow-melt and high surface runoff. This stream does not provide fish habitat.

Near its confluence with Upsalquitch Lake, Charlotte Brook has a stream channel width of approximately 4.5 m and an average depth of 20 cm. Due to its greater width, the stream channel is more open to sunlight along this stretch. The stream gradient is lower than that observed further upstream near the proposed minesite. The stream bottom consists of sand, gravel, and boulder-sized material. Fallen logs, boulders and undercut banks provide shelter for brook trout. On 29 June, 1989, the water temperature at this location was 16°C.

Upsalquitch Lake has a surface area of approximately 68 hectares and an average depth of approximately 5 m (15 m maximum). The lake is oligotrophic with typically clear water and sparse aquatic vegetation (emergent 2%, submerged 5%). The lake stratifies completely in the summer. Early surveys conducted by DNRE indicate that the lake supports populations of brook trout, arctic char, lake chub and fallfish. However, more recent surveys have failed to confirm the presence of arctic char and fallfish (A. Madden, DNRE, personal communication, 1989).

The large rearing area and more favourable summer temperatures provided by the lake promote increased production and growth rates of brook trout than those experienced by populations in the headwaters of the inlet streams. The usual size of trout caught in the lake is 150-200 mm.

Upsalquitch Lake is drained by the Southeast Upsalquitch River. The river appears to provide ideal trout habitat from the lake to the Southeast Gorge. It has an average width of 8 to 10 m and an average depth of 30 cm. Its banks are lined with dense alder growth which hangs in and over the water providing cover for brook trout. Various cold water brooks enter at several points along this stretch of river. The water from these brooks help temper the warmer lake water and contributes to the high quality brook trout habitat.

At the Southeast Gorge, the Southeast Upsalquitch River spills over a fall. The waterfall prevents the movement of Atlantic salmon and other fish species upstream beyond this point. From the junction with the Northwest Upsalquitch River to its confluence with the Restigouche River, the Upsalquitch River increases dramatically in size and is more characteristic of a salmon river rather than a brook trout stream.

4.2.3 Aquatic Resources

Baseline data on stream populations of fish and benthic invertebrates were collected during 1989 and the development of this data base is ongoing. The baseline data will be updated with further sampling on a seasonal basis during 1990 to document the variability of the aquatic community over the course of the hydrologic year. This program will be expanded in 1990 in order to characterize the aquatic resources of Upsalquitch Lake.

4.2.3.1 Fisheries Resources

Although Charlotte Brook is too small and alder tangled to receive much fishing pressure in the vicinity of the minesite, it does support a population of small brook trout. The electrofishing survey results for sites CB-1, CB-2b (upstream of proposed diversion) and CB-3 in the vicinity of the minesite (Figure 4-5) are presented in Table 4-9. The results indicate that total trout densities range from about 50 to 150 fish per 100 m^2 at these locations. The patchy distribution of fry appears to be responsible for the wide range in total densities - at site 2, 120 fry per 100 m^2 were found, while at site 3 no fry were captured. Dense populations of brook trout were also found at sites CB-4 and UR-5, in

TABLE 4-9

Summary of Electrofishing Results for Sites in the Vicinity of the Restigouche Property, 28-29 June 1989

Site No.[1]	Location	Species	Age	Density (No. fish/100m^2)[2]	90% Confidence Interval
CB-1	South Branch	Brook Trout	0+	*[4]	
	Charlotte Brook		1+	28.3	
			2+	19.5	
			Total	53.4	
CB-2b[3]	North Branch	Brook Trout	0+	120.8	± 4.4
	Charlotte Brook		1+	23.2	
			2+	8.7	
			Total	152.3	± 4.0
CB-3	Charlotte Brook	Brook Trout	0+	0	
			1+	66.4	
			2+	34.1	
			Total	99.7	± 11.8
CB-4	Charlotte Brook	Brook Trout	0+	21.5	± 8.4
	Near Lake		1+	72.0	± 12.0
			2+	28.2	
			3+	0.4	
			Total	117.9	± 17.4
UR-5	S.E. Upsalquitch	Brook Trout	0+	76.8	
	River Near Lake		1+	15.2	
			2+	1.2	
			3+	1.0	
			Total	92.8	

Electrofishing survey was conducted by R.A. Currie.

1. Refer to Figure 4-6.
2. Zippin formula (Zippin, 1958).
3. Site 2 was electrofished on 23 September 1989.
4. Could not be calculated due to non-decreasing catch pattern.

Charlotte Brook and the Southeast Upsalquitch River near the lake. These densities are comparable to those observed in other streams in this area where brook trout is the only fish species present. Sampling site descriptions are included in Appendix J.

The factors promoting such dense populations in the brook include adequate spawning habitat, excellent water quality, an abundance of cover and a lack of competition for resources from other fish species. The cooler temperatures of these northern, well-shaded (and probably spring fed) brooks results in very slow growth rates for these trout. The combination of slow growth rates and a short life span (probably 3 or 4 years) results in populations of relatively small fish (<150 mm).

Upsalquitch Lake is relatively unique in the area and supports a very popular trout fishery. In 1985 for example (the most recent year of comprehensive angling surveys), Upsalquitch Lake received a total of 1004 angler days of effort during the season. This effort produced an estimated 11,116 brook trout. In spite of the intensive sport fishery, this lake continues to produce an abundance of small (100-200 mm) brook trout. The intensive fishery may be responsible for a decrease in the average size of trout that has been observed during the past few years.

The Southeast Upsalquitch River drains Upsalquitch Lake. The 11 km of river from the lake to the Southeast Gorge Falls supports a significant trout fishery. This section of the Southeast Upsalquitch River is too shallow to run by canoe so most fishing is done on foot.

The stretch of water from the Southeast Gorge to a point approximately 14 km downstream is closed to fishing. Immediately downstream of the closed water are the Southeast Upsalquitch Crown reserve fishing waters. This Crown reserve stretch extends downstream to the confluence of the Northwest Upsalquitch River at the Forks (Figure 4-1). Crown reserve waters provide exclusive fishing rights to anglers selected in a draw. The Upsalquitch River system has a total of six Crown reserve stretches. Four of these stretches are directly influenced by water from Upsalquitch Lake - the Southeast Upsalquitch Stretch (upstream of the Forks), the Forks Pool Stretch, the Crooked Rapids Stretch and Berry Brook Stretch. The remaining two stretches are in the Northwest Upsalquitch tributary.

In addition to Crown reserve salmon angling, there are also 12 private lodges on the Upsalquitch River and Restigouche River downstream of the confluence of the Upsalquitch River. These camps employ approximately 80 persons (managers, guides, cooks, etc.) during the three month fishing season. Assuming half of the camp staff are guides, and each guide is responsible for one guest, then it is likely that the private lodges accommodate about 40 anglers each day throughout the season.

In addition to camp personnel, the Restigouche Riparian Association employs approximately 48 private wardens to patrol the river system during the summer and fall months. Approximately 18 of these wardens are responsible for waters between Upsalquitch Forks and the estuary.

The 1985 angling survey estimated that the Southeast Upsalquitch River received 1, 260 angler days of fishing effort. This effort resulted in a catch of 549 salmon and 10,335 brook trout. The Upsalquitch River (downstream of the Forks) received 5,795 angler days of effort resulting in a catch of 877 salmon and 29,028 brook trout.

The sport fishery in the Upsalquitch drainage area must be considered significant in terms of current dollar value. If it is assumed that the level of trout fishing effort on Upsalquitch Lake in 1989 was the same as occurred in 1985 (1004 angler days) and a current value of $14.32/angler day of trout fishing for a resident angler (DNRE's 1985 estimate of $12.26/angler day compounded to current value) then this fishery alone would have a value of $14,377.

The trout fishery in the Southeast Upsalquitch River is more difficult to evaluate since only total effort (angler days) is reported and there is no distinction in the number of angler days for trout or for salmon. However, if it is assumed that half of the total effort was for trout (630 angler days) and using the same assumptions as above, then the brook trout fishery in the Southeast Upsalquitch River and Upsalquitch Rivers can be estimated for the three main groups - effort from the four previously mentioned Crown reserve stretches, effort from two stretches of leased waters, as well as effort from anglers fishing freehold (private) water. In 1988 the crown reserves provided a total of 803 angler days of effort. Assuming the same level of effort in 1989, and a value of $200/angler day (M. Redmond, DNRE, personal communication, 1989), this would suggest a total value of

$160,000 for the Crown reserve angling. Similarly, the angling leases in 1988 accounted for 446 angler days of effort. Assuming the same level of effort in 1989 and an estimated value of $600/angler day (M. Redmond, DNRE, personal communication, 1989) the leases provide a total value of $267,600. There is no estimate of effort for the freehold stretches of water in the Upsalquitch drainage so it is not possible to calculate the estimated value of these fisheries.

A total of the values already determined, however, suggests that the sport fisheries in the Upsalquitch drainage had a value in excess of $450,000 in 1989 (underestimated since this figure does not include freehold fishing or Crown reserve stretches in the Northwest Upsalquitch River, or trout fishing along any of the many tributary streams). It is important to note that most of this money is spent locally employing wardens, guides, camp staff, purchasing supplies, etc.

4.2.3.2 Benthic Invertebrates

Preliminary sampling of benthic invertebrate populations was conducted in Charlotte Brook and the Southeast Upsalquitch River using mini pot samplers. Samplers were installed on June 28, 1989 at sites 1, 2, and 3 (Figure 4-6). On June 29, samplers were installed at sites 4 and 5. Three samplers were deployed at each site. Samplers were collected from each site at approximately 30-day intervals. Samples are currently being identified and analyzed. Results of the invertebrate population sampling program are expected in March, 1990.

Qualitative observations indicate that the aquatic environment in the vicinity of the proposed minesite supports a rich benthic invertebrate community. The stretch of river downstream of Upsalquitch Lake appeared to have very dense populations of benthic invertebrates.

To provide a reliable basis of comparison, invertebrate population data must be collected in all seasons. The benthic sampling program will continue in the coming seasons in order to characterize the annual variability of invertebrate populations in the vicinity of the proposed minesite.

4.3 Summary of Pertinent Baseline Data

The proposed minesite is located in a remote, rugged region of northern New Brunswick. Vegetation in the vicinity of the site is typical of the uplands forest component of the Acadia Forest Region. It is a mixed forest with predominantly fir and spruce. Logging activity has taken place near the site in previous years.

Most wildlife species native to north central New Brunswick occur in the area. There is no known critical wildlife habitat in the vicinity of the site. The nearest wintering habitat for deer is located approximately 2 km away.

Principal land use in the area consists of forestry operations, hunting, campsite leases, and proposed ecological reserves. There are no forest harvesting operations scheduled for the vicinity of the proposed mine site in the near future. Campsite leases occur downstream of the site on lower Charlotte Brook and on Upsalquitch Lake. The nearest of the proposed ecological reserves is located more than 6 km downstream on the Southeast Upsalquitch River. Other uses include trapping, sugar bush leases, fiddlehead harvesting, and various non-consumptive recreational uses.

The site is situated on typically thin stony till which comprises silty sand and gravel with cobbles and boulders. Clayey sands and gravels also occur. The volcanic bedrock is generally well jointed and weak to moderately strong, being completely weathered in some locations.

The general area of development lies within a volcanic rock unit of Ordovician age with a sequence of rhyodacite and rhyolite tuffs and flows occurring above and below the massive sulphides. The massive sulphides outcrop at the surface by Charlotte Brook and dip northwards by 25° in a 10-50 metre thick zone. No faulting has been identified in the vicinity of the deposit.

The proposed minesite is located close to the drainage divide between the Upsalquitch and Nepisiguit rivers. Local systems of groundwater flow are relatively shallow and groundwater flow directions are largely influenced by surface topography. Most of the mine development is in a recharge area with significant depths to the water table. Groundwater is discharged to the surface system at Charlotte Brook.

The annual rate of recharge to the groundwater system is estimated to be 65 mm. This flux of groundwater infiltration is moved from the recharge area to the discharge area beside Charlotte Brook with the water table at 10 to 25 metre depths.

Drainage from the site is to Charlotte Brook in the extreme headwaters of the Southeast Upsalquitch River. Charlotte Brook consists of two small branches at the site with an estimated mean annual flow of 0.1 m^3/s at their confluence. Charlotte Brook is the major tributary of Upsalquitch Lake. The lake is drained by the Southeast Upsalquitch River.

Water quality in this river system is generally excellent and supports a variety of aquatic life. The surface water is low in dissolved minerals, soft due to low calcium and magnesium, has pH values exceeding 7, and slightly alkaline (a measure of buffering capacity of water against changes in pH). Immediately downstream of the deposit, iron and zinc were only slightly elevated.

Elevated concentrations of heavy metals occur in stream sediments immediately downstream of the site. This reflects the presence of the known sulphide mineral deposit.

Within the Upsalquitch system, fish species of prime concern are Atlantic salmon and brook trout (resident and sea-run). The waterfall below Simpson's Field limits the upstream range of Atlantic salmon and sea-run brook trout, but brook trout are ubiquitous throughout the river system.

Total brook trout densities are relatively high. Dense populations were found in Charlotte Brook and the Southeast Upsalquitch River near the lake. The high productivity is related to the habitat quality and lack of competition from other species. Upsalquitch Lake also supports productive trout populations.

Upsalquitch Lake is in a relatively lake-poor region of the province and is subject to an intense brook trout sport fishery. The Southeast Upsalquitch River supports Atlantic salmon and brook trout sport fisheries. Four Crown reserve stretches are situated downstream of the proposed mine site. Records of angling from these stretches show that the angling quality for Atlantic salmon in the Southeast Upsalquitch River is very good. Twelve private fishing lodges also occur downstream of the site.

The sport fishery in the Upsalquitch drainage is considered significant in terms of current dollar value. The value of the Upsalquitch Lake sport fishery is estimated at approximately $14,400 for 1989. The 1989 value of Crown reserve angling and private leases are estimated to be $160,000 and $267,000, respectively.

5.0 ENVIRONMENTAL IMPACT ASSESSMENT - DEVELOPMENT/CONSTRUCTION

Development/construction activities required by the proposed project and the relevant biophysical setting for these activities are described in this section in order to identify potential environmental effects. Potential negative effects will be described in the context of proposed mitigation.

Due to the distance of the various land uses in the area (Section 4.1.3) from the minesite, no negative impacts have been identified. Spatial bounds for impact assessment include the area extending 1 km around the minesite and haulage road, and water courses adjacent to the minesite.

Generally, standard construction practices will mitigate potential environmental concerns. However, certain environmentally sensitive areas have been identified within the study bounds which may be at risk during the development/construction phase.

5.1 On-site Facilities

Construction of on-site facilities will involve the clearing of land, excavation, installation of earthwork structures (ponds, pads, ditches), foundation and erection of various shops and other small buildings. Clearing, excavation, and earthworks will involve the use of bulldozers, power excavators and trucks. Excavated materials will be used for construction of drainage collection and waste treatment facilities. Erection of the structures and equipment will involve the use of erection hoists, air compressors, welding machines, and pneumatic wrenches.

Noise and dust emissions would occur during all phases of the mining operation (construction, blasting, loading and haulage operation). These emissions would be similar to those for other quarry and open-pit mining operations.

Generally noise may be defined as sound which is undesired by the recipient. The volume and quality of noise determine the type of response elicited. Noise acceptable to humans for various land uses may or may not be acceptable to wildlife.

Figure 5-1 presents a graph indicating different noise levels from various sources, typical reactions and whether levels are considered acceptable or unacceptable for indoor or outdoor environments. In addition to heavy trucks, which generate 90 dB at 15 metres, common Canadian and American references indicate the following noise levels can be expected (at 15 metres from source unless stated otherwise) from the typical equipment which may be utilized:

Pneumatic Drill	80 to 110 dB
Crawler Tractors	85 to 90 dB
Motor Scrapers	90 to 95 dB
Air Compressors (at 3 metres)	100 dB
Jack Hammer (at 8 metres)	90 dB
Cement Mixer (at 6 metres)	80 dB

FIGURE 5-1

Common noise levels and typical reactions

Sound Source	Noise Level	Apparent Loudness	Typical Reaction	CMHC Requirements		
				Categories	dB	Maximum Acceptable Levels
	dB 135		Painfully loud			
Military Jet	130	Sixty-four times as loud	Limit amplified speech			
Jet takeoff at 200'	120	Thirty-two times as loud				
	110	Sixteen times as loud	Maximum vocal effort	Unacceptable		
Jet takeoff at 2,000'	100	Eight times as loud				
Freight Train at 50'	95					
Heavy truck at 50' Busy city street	90	Four times as loud	Very annoying Hearing damage (8 hours)			
	80	Twice as loud	Annoying			
					75	
Highway traffic at 50'	70	Base reference	Telephone use difficult	Unacceptable without adequate sound insulation		
	60	Half as loud	Intrusive			
Light car traffic at 50'					55	Outdoor Recreation
Noisy office	50	Quarter as loud	Speech interference	Normally acceptable	45	
					45	Kitchens Bathrooms
Public Library	40	Eighth as loud	Quiet		40	Living/Dining
					35	Bedrooms
Soft whisper at 15'	30	Sixteenth as loud	Very quiet			
	10	Sixty-fourth as loud	Just audible	Acceptable		
Threshold of hearing	0					

NOTE: The minimum difference in noise level that is noticeable to the human listener is 3 dB. A 10 dB increase in level appears to double the loudness while a 10 dB decrease halves the apparent loudness.

Source: Canada Mortgage and Housing Corporation, 1977.
Rail and Road. Effects on Housing C.M.H.C
Publication NHA 5156, December.

The unit dB refers to sound level in decibels. It is based on the A-weighted, 24-hour equivalent sound level used by Canada Mortgage and Housing Corporation (CMHC). The A-weighted sound level is the sound level as measured on a sound level meter, using a setting that emphasizes the middle frequency components similar to the response of the human ear. The A-weighted sound level is found to correlate well with subjective assessments of the annoying or disturbing effects of sound. Although often expressed as dBA, it will be referred to as dB in this document.

Most of the equipment listed generates noise in the 80 to 110 dB range up to 15 metres from the source. Although these are in the unacceptable range, the noise levels which may exist at various locations will depend upon several factors. These factors include the frequency and duration of equipment use, the combination of equipment used, the distance from the source, the absorptive capacity of ground materials and the topography and vegetation around the minesite.

Using general rules of thumb as an indicator, 80 to 110 dB at the source would be attenuated in the air by distance alone, so that the levels at 1 km from the source would be expected to be intermittently in the 45 dB to 60 dB range.

Outside of the minesite, dwellings nearest the construction will be those located on camp leases on Charlotte Brook and Upsalquitch Lake. The nearest camp will be approximately 4 km from the minesite. The actual levels experienced at the camps should be minimal since the absorptive capacity of the intervening ground materials and vegetation should be quite high. Other than during the excavation period, the construction of the various facilities should generate little noise.

Noise generated by human activities may affect wildlife populations. Noise produced by such activities can either attract individual animals or induce panic and result in the withdrawal of a population from a previously used area.

The effect of noise on wildlife is related to the type of noise emitted, its intensity and frequency and the distance from the animals. The effect of mining operations on wildlife has received little study. However, Kuck et al., (1985) investigated elk calf and cow response to simulated mine disturbances. Simulated mine noise, with an approximate volume of 100 dB at 3 m was used. It was found that, compared to undisturbed elk, disturbed animals moved greater distances, used larger areas and lacked selection for favourable habitat. The distance of effect was not specified but appeared to have been within several hundred metres.

Other studies have been conducted on various types of human disturbances with several wildlife species. These studies are summarized in Table 5-1. The results indicate that disturbances elicit no response when the source of disturbance is located several hundred metres from the animals.

TABLE 5-1

Effect of Various Types of Human Related Disturbances on Some Wildlife Species

SPECIES	TYPE OF DISTURBANCE	DISTANCE OF EFFECT	BEHAVIOURIAL RESPONSE	SOURCE
Elk	Simulated Mine Noise (approximately 100 dB at 3m)	Not Specified (several hundred metres)	- moved 1.7 times farther - made 3.5 times greater elevation change - used 5.5 times the area - showed greater use of unfavourable habitat	Kuck et al., 1985
White-tailed Deer	Snowmobile traffic	Not Specified (proximate)	- increased home range size - increased movement - displaced to other areas - some habituation to disturbance by unhunted deer	Dorrance et al., 1975
		≤ 61 m	- moving ≥ 23 m farther away - little effect on overall winter movements - deer probably accustomed to noise of machinery and powersaws which decreased reaction to snowmobiles. - deer remained close to noisy heavy equipment and men working with powersaws, but moved away when approached silently.	Eckstein et al., 1979
Caribou	Small Aircraft (fixed wing)	< 60 - 150 m > 150 m	- panic, running, flight - no reaction	McCourt et al., 1974 Calef et al., 1973; 1976
	Compressor (same frequency and intensity as a jet engine)	< 200 m > 800 m	- avoided area - no reaction	McCourt et al., 1974
Moose	Small Aircraft (fixed wing and helicopter)	< 61 m > 180 m	- strong reaction - no reaction	McCourt et al., 1974

Some species, such as white-tailed deer, may be attracted to certain activities which may provide a source of forage. Deer have also shown habituation to various types of disturbance.

The proposed minesite is approximately 2 km from the nearest deer wintering area along Simpson's Brook. Available information on noise effects indicate that noise generated by mining activity would not result in adverse effects on deer populations in the area. Due to the proximity of Highway 180 to the deer yard, it is likely that the deer in the area are accustomed to noise levels associated with highway traffic.

Apart from construction activity itself, excavation operations tend to generate dust both on site and along haulage routes leading to and from the site. Dust from the site and roadway is affected by both site and weather conditions (rain and wind direction) as and by preventative measures which may be taken. These include care with loading and trucking as well as cleaning and treatment of haulage routes. Since excavated material will be disposed of on-site, dust related problems should be minimal.

Site runoff during this phase may not be of acceptable quality to permit direct off-site release. The runoff may contain increased suspended solids or contaminants which may be leached from soil at the site. Runoff is not expected to be acidic because acid generating rock would not be exposed until all waste treatment facilities are operational.

5.1.1 Proposed Mitigation and Residual Effects on Terrestrial Environment

The noise will be attenuated by the surrounding topography (within a 2 km radius the rise in elevation of land ranges from 40 to 100 m, providing a natural barrier to the propogation of sound) and vegetated terrain and is not expected to be a source of adverse environmental effects. However, noise levels will be monitored at selected locations to determine the accuracy of predicted levels. This information will be used in the design of mitigative measures, as required. This may include provision of sound barriers at appropriate locations around the mine site.

As mentioned previously, dust emissions are expected during all phases of the mining operation. Surface dust emissions will be controlled by the use of water sprays and dust suppressants. Some air borne particulates are anticipated to result from normal pit operations for ore extraction (blasting, loading, ore haulage, etc.). However, the amount of ore dust is expected to be minimal due to the hardness of the ore to be mined. Hard rock produces little dust when broken, and therefore is expected to generate relatively little air borne dust. Dust arising from the pit is expected to be blown in a generally easterly direction by the prevailing winds, paralleling the valley of Charlotte Brook. Therefore, most of the dust will settle on the ground and vegetation adjacent to the minesite. Dust emissions are not expected to have any deleterious effects on either the terrestrial or aquatic environment.

Residual effects on the terrestrial environment during the construction period will include the elimination of vegetation and wildlife habitat in the disturbed areas. The presence of vast tracts of similarly forested terrain adjacent to the minesite area will adequately absorb the loss of wildlife habitat.

5.1.2 Proposed Mitigation and Residual Effects on Aquatic Resources

The temporary and permanent collection, and diversion ditches and associated sedimentation ponds will be constructed prior to the clearing and grubbing on the site to ensure the availability of adequate sedimentation capacity. The temporary facilities will be located at the Charlotte Brook end of the open pit to collect drainage during excavation of the pit overburden prior to the initial development of the pit proper (see Figure 3-2). No residual effects due to site construction have therefore been identified.

5.2 Off-site Facilities

5.2.1 Haulage Road

Construction of the mine haulage road would involve activities similar to preparation of the minesite (bulldozing, earth moving, etc.). As such, the same potential effects are considered. The effects of haulage road construction on land use and the terrestrial environment will be minimal.

5.2.2 Charlotte Brook Diversion

Planning for the diversion of the north branch of Charlotte Brook will include a strategy for limiting the impacts on the aquatic habitat and fish populations below the proposed site. The potential negative impacts of diverting the north branch include loss of fish habitat and release of sediments into the downstream section of Charlotte Brook.

5.2.2.1 Proposed Mitigation and Residual Effects on Aquatic Resources

The diversion channel will be constructed completely "in the dry". Closed-off conditions will be maintained at both the upper and lower ends until all construction has been completed. All construction activity in close proximity to the stream will be kept to a minimum. The lining of the channel with "clean" gravel and stones will prevent erosion from the sides once the channel is in operation. Therefore, no release of sediment into the downstream sections of Charlotte Brook will result from construction of the diversion channel.

The diversion channel will be designed to have a flow capacity which is equivalent to the existing section of the north branch. This will be determined by observations of the existing cross sectional profiles, invert slope and high water marks. The proposed diversion of the north branch of Charlotte Brook into the south branch will be constructed to ensure that the productivity of the existing section of the north branch is adequately replaced. A diversion structure providing the parameters of idealized brook trout habitat would include:

- Pool periodicity of one every 5 to 7 channel widths
- 50/50 pool/riffle frequency

- Riffle gradient of 1%
- Overhead cover provided by cobble and boulder-size material placed in both pools and riffles

The pools would be constructed through impoundment of the stream by rock-filled weirs. They would also be excavated to bring the normal pool depth to at least 30 cm. At least 20% of the diversion would contain cobble or boulder to provide overhead cover. A detailed habitat characterization program will be undertaken to evaluate and quantify the existing conditions. Upon review of the quantified habitat data, channel design parameters will be modified accordingly. The diversion channel features will be defined and reviewed with the appropriate agencies during application for a Watercourse Alteration Permit.

The section of the south branch between the outlet of the diversion channel and the present confluence of the north and south branches (approximately 110 m in length), will receive increased flow due to the diversion. This section consists primarily of a cut through surface bedrock zones. The bottom of this section is well lined with gravel and stones. Hence, there is not expected to be increased erosion in this section due to the increased flow. Hydraulic features of the existing channels will be reviewed and detailed design parameters will be developed for the diversion channel to ensure that the hydraulic capacity of this section is not exceeded. Detailed design features will be provided in the application for approval to construct. No residual effects due to diversion construction have been identified.

5.2.2.2 Habitat Characterization

Following finalization of the location of the proposed diversion channel a detailed habitat characterization program will be conducted in that section of the north branch of Charlotte Brook. Habitat parameters will be quantified to determine the amount and quality of various habitat types to be replaced.

This work will be conducted early in the summer of 1990, as conditions permit. The program will involve measuring physical stream parameters and electrofishing to verify habitat utilization. Information obtained will facilitate diversion channel design modifications to provide compensation-in-kind for habitat loss in Charlotte Brook.

6.0 ENVIRONMENTAL IMPACT ASSESSMENT - OPERATION

This section of the report assesses the effect of mine operation on the biophysical and socio-economic environments. Review of the proposed mine operation has identified the following components as being of potential environmental concern:

- liquid waste effluents
- blasting
- groundwater
- ore trucking
- operation interruption
- socio-economic effects
- cumulative effects

The interactive approach to the design of the proposed mine and the experience gained through operation of other similar facilities in the province has resulted in the identification of mitigative measures which will be incorporated into the project systems.

Potential effects of the operation of the Restigouche mine on the terrestrial environment are limited to the immediate area of the mine and haulage road and are expected to be similar to those associated with the development/construction phase (see

Section 5.0). No additional mitigative measures are required and the environmental impact assessment of the mine operation will primarily consider potential effects on the aquatic environment.

The Restigouche ore body is located in close proximity to Charlotte Brook which is a major inflow to Upsalquitch Lake. Charlotte Brook and Upsalquitch Lake are located in the headwaters of the Southeast Upsalquitch River. Uncontrolled discharge of untreated effluent from the minesite could have serious effects on the water resources and aquatic environment in Charlotte Brook. Large volume or persistent discharge of untreated effluent could have negative effects on the water quality of Upsalquitch Lake and the Southeast Upsalquitch River. The spatial bounds for the assessment of potential impacts on the aquatic environment have, therefore, been determined to be the Southeast Upsalquitch drainage. However, measures will be taken to ensure that the water quality of Charlotte Brook remains suitable to sustain the resident populations of aquatic biota. To do so will ensure that the project will have minimal effect within the identified project bounds.

6.1 Liquid Waste Effluents

6.1.1 Potential Effects of Acid Mine Drainage on Water Resources and the Aquatic Environment

The potential effect of mining operations on the quality of surface and ground waters is the most prominent environmental concern related to the mining of sulphide orebodies. The generation of acidic drainages is initiated during the mining phase and can remain long after closure of the operation due to the continued access of air and water to the sulphides. If unchecked, the release of these drainages into the environment can drastically affect the quality of surface and ground waters, near and remote from the minesite, and consequently the species that inhabit or otherwise depend on these resources.

A worst case situation would occur if untreated or inadequately treated acidic drainage enters Charlotte Brook. Any loss of untreated or inadequately treated drainages into Charlotte Brook would be unacceptable. Due to the relatively small flow in this receiving stream, a spill would be very detrimental to water quality, resulting in a plume moving from the minesite to Upsalquitch Lake. However, upon reaching the lake the spill would be effectively diluted by the large volume of water in the lake. This would result in minimal effects on Upsalquitch Lake, being limited to the area near the outlet of Charlotte Brook. A summary of the effects on water quality, during low-flow runoff conditions, is given in Table 6-1 and 6-2.

A spill of untreated effluent would contain elevated levels of various metals. In this context concerns about metals relate to their acute availability and bio-toxicity and the potential for bioaccumulation and hazards to human health. The toxicity of metals to aquatic biota appears to be dependent upon the concentration of free, metals rather than total metals (Borgmann, 1983). Metal toxicity in the aquatic environment is greatly influenced by the physio-chemical factors of the specific recipient environment. Speciation

TABLE 6-1

Potential Effects of Spills on Water Quality

Quantity of Spill	3000 m^3 (holding pond volume)
Acidity of Spill (mg/l)	1500 (as $CaCO_3$)
Flow Conditions	low-flow, assume no dilution
Effects on Charlotte Brook	plug-flow; water quality in stream is equivalent to water quality of spill
Effects on Upsalquitch Lake	water quality effects would occur at outlet of Charlotte Brook; maximum acidity increase in Lake is <1mg/l
Effects on SE Upsalquitch River	none

TABLE 6-2

Potential Effects of Inadequately Treated Discharges on Water Quality

Quantity of Spill	85 m^3/h (design treatment flowrate)	
Effluent Quality	untreated (partially treated)	
Effluent Acidity as $CaCO_3$ (mg/l)	1500 (1.0)	
Flow Conditions	summer flow	
Duration of Discharge (hours)	12	24
Concentrations in Brook (mg/l)		
at minesite	500 (0.3)	500 (0.3)
at Lake	200 (0.1)	200 (0.1)
Maximum Concentrations in Lake (mg/l)	0.3 (<0.001)	0.6 (<0.001)
Effects on SE Upsalquitch River	none	none

and bio-availability of metals in water are controlled by physical and chemical interaction which may be affected by numerous environmental factors. Generally, metal toxicity decreases with an increase of pH, dissolved oxygen, hardness, alkalinity, dissolved salts (Ca^{++} and Mg^{++}), and in the presence of chelating agents (Babich and Stotzky, 1983). Both inorganic and organic metal complexes appear to be relatively non-toxic, reducing toxicity on a total metal concentration basis (Borgmann, 1983).

Metals are readily bioaccumulated by fish, being found mainly in the gills, liver, and fin tissues, and less in the edible muscle tissue (Merlini and Pozzi, 1977). Aquatic organisms have developed a variety of mechanisms for depurating heavy metal pollutants. When the source of contamination is removed, metal levels in fish will decrease through elimination (Weis and Weis, 1983; Niimi, 1983).

Biomagnification may result when a substance which is resistant to degradation is transferred through the trophic levels of the aquatic food web. The extent of biomagnification depends upon factors such as the number of stages in the food web, kinds of organisms, and the concentration of the substance at each level of the web (Ray and Trieff, 1980). However, metals such as copper and lead have not been shown to biomagnify to any great extent in the aquatic environment (Hutchinson et al., 1976; Namminga et al., 1974; Getz et al., 1977).

The release of untreated effluent would probably result in acute toxic effects on the aquatic invertebrates and fish in Charlotte Brook. Some metal bioaccumulation may occur but biomagnification would not be expected to be a problem. The effects would be of a temporary nature. Studies of other such spills in the province have shown that once the source of contamination is eliminated, the ecology of the stream recovers within a time-frame of months. Any effects on Upsalquitch Lake would be limited to the area near the outlet of Charlotte Brook. The large volume of water contained by the lake would effectively dilute even the most severe spills.

The discharge of inadequately treated effluents into Charlotte Brook, for various undetected periods of time, would have similar effects as those for a spill. Thus, as shown in Table 6-2, effects on the brook would be detrimental to water quality and aquatic biota, while the effects on Upsalquitch Lake would be minimal.

6.1.1.1 Proposed Mitigation and Residual Effects

Measures will be incorporated at the Restigouche site to ensure the containment and treatment of acidic drainages. The quantity of acidic drainages that would be generated will be minimized by:

- separation of non-sulphide from sulphide waste rock, and
- diversion of uncontaminated surface runoff away from the sulphide areas.
- waste material management as indicated in section 3.2.

The drainage control and effluent monitoring system would be designed and operated to ensure that the failure of any of the ponds, ditches and related equipment leads to discharge of water into the open pit. The open pit, when completed, would have the capacity to contain more than two year's production of contaminated water. Hence, the pit would provide an emergency reservoir should the need ever arise for the temporary storage of drainages.

The drainage will be contained by appropriately lined pads, ditches and holding ponds. The treatment system will ensure neutralization and reduction of metallic contaminants from acidic drainages prior to their discharge into Charlotte Brook (see Section 3.2.3).

Treated effluent will be discharged into Charlotte Brook. Effluents treated in accordance with the Metal Mining Liquid Effluent Regulations (see Table 6-3) contain residual metals that could affect the water quality of a small receiving stream such as Charlotte Brook under the low flow conditions given in Table 4-7. Analysis has determined that discharge of design quantities of effluent, which meet the regulatory standards given in Table 6-3, could result in concentrations exceeding those necessary for protection of aquatic life in Charlotte Brook during low flow periods. The treatment facilities will therefore be designed and operated to meet the more stringent values given in Table 6-4. The potential effects of the chronic release of the residual metals are illustrated in

TABLE 6-3

Metal Mining Liquid Effluent Regulations

Substance	Max. Authorized Monthly Arithmetic Mean Concentration (mg/l)
Arsenic	0.5
Copper	0.3
Lead	0.2
Nickel	0.5
Zinc	0.5
Total Suspended Matter	25.0

Source: Environment Canada, 1977.

TABLE 6-4

Objective Parameter Levels for Treatment Facility Effluent

Parameter	Objective (mg/l)	Comparative* Effluent Regulation (mg/l)
Copper	0.05	0.3
Iron	0.50	N/A
Lead	0.05	0.2
Zinc	0.50	0.5
pH	9.5	≥ 5

* See Table 6-3
N/A Not Applicable

Table 6-5. Effluent with concentrations of metals at the objective levels given in Table 6-4 would result in concentrations in Charlotte Brook within the range of values considered safe for continuous exposure of salmonids. These values are well below lethal levels.

As mentioned previously, total metal concentration does not reflect the actual toxic component. Toxicity under natural conditions generally cannot be predicted from extrapolated laboratory studies due to the numerous modifying factors acting on the metal and on the exposed aquatic organism. Metals do not degrade, but are transferred or stored in the aquatic environment and can be considered available only under appropriate conditions. Metals may be strongly adsorbed to particles and removed from the water column and concentrated in sediments. Sediments and surface film are important sites of metal enrichment and this is reflected in the analytical results for the stream water chemistry and geochemistry (see Sections 4.2.1.1 and 4.2.1.2). Metals will also complex with organic and inorganic ligands.

Metal concentrations in Charlotte Brook, resulting from the discharge of treated effluent, will be below toxic levels. Due to the factors discussed previously, metals are expected to be largely unavailable to aquatic biots. Therefore, no problems with metal toxicity are expected to arise from in the mine effluent.

Bioaccumulation may be expected to occur to some extent. As mentioned previously, metals tend to concentrate in the liver, gills, and fin tissues in fish, with much

TABLE 6-5

Potential Effects of Residual Metals in Effluent Discharged to Charlotte Brook

Quantity of Discharge	34 m^3/h (summer nominal effluent flowrate)			
Effluent Quality	objectives (copper 0.05; iron 0.5; lead 0.05; zinc 0.5)			
Flow Conditions	summer low flowrate (0.05 m^3/s)			
Concentration (mg/l)	copper	iron	lead	zinc
- in Charlotte Brook at minesite	0.008	0.08	0.008	0.08
- safe concentration for continuous exposure of fish	0.009[a]	7.5[b]	0.058[c]	0.036[d]
- lethal level	0.025[e]	--	4.82[f]	0.093[g]
Effects on Charlotte Brook	none			
Effects on Upsalquitch Lake	none			
Effects on S.E. Upsalquitch River	none			

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[a] brook trout, Cu^{++}; McKim and Benoit, 1971.
[b] brook trout; Sykora et al., 1972.
[c] brook trout, total lead; Holcombe et al., 1976.
[d] rainbow trout; Goettl et al., 1976.
[e] Atlantic salmon, incipient lethal level; Carson and Carson, 1972.
[f] brook trout, mean acute toxicity; US EPA, 1985.
[g] rainbow trout, 96-h LC_{50}; Chapman, 1978.

less in the edible muscle tissue. Although bioaccumulation may occur, wholebody metal concentrations would be expected to decrease with increasing trophic level, due to organ-specific accumulation and metabolic regulation in most consuming organisms (Hutchinson et al., 1976).

The monitoring program will have provision for monitoring fish body metal contaminant burdens for selected locations. Mitigative measures will be developed if body burdens of fish within the influence of the mine approach problematic levels.

During low flow conditions, the contaminated water would consist only of groundwater inflow to the open pit. If necessary, this water will be stored in the pit until more favourable runoff conditions exist. The above-noted mitigative measures will protect the water quality of Charlotte Brook and the Southeast Upsalquitch drainage. No residual effects are expected.

6.1.2 Potential Effects of Other Liquid Waste Discharges on the Aquatic Resources

Other liquid discharges from the site will include surface drainage from the non-sulphide waste rock disposal area. This drainage would contain suspended solids and would have the potential to increase sediment loadings in Charlotte Brook.

6.1.2.1 Proposed Mitigation and Residual Effects

Mitigative measures will include diversion ditches, to minimize the quantity of surface runoff that contacts the site, and a sedimentation pond to ensure the removal of suspended solids prior to discharge of the drainage into Charlotte Brook. No residual effects are expected.

6.2 Blasting

The use of explosives is common practice in the development of mineral resources. As indicated in Section 3.1, both ammonium nitrate-fuel oil based explosives and high explosives will be used in the mining operation. The frequency of blasting will probably not exceed one blast per day.

6.2.1 Potential Effects on Aquatic Resources

Indiscriminate use of explosives in or near waterbodies is potentially harmful to fish. When detonated, explosives release large quantities of energy over a brief interval of time. Pressure generated from an explosion produces a shock wave in the surrounding medium (air, water and soil) which attenuates over distance. Explosives detonated underground produce pressure waves within the earth which are propagated as body waves or surface waves. Two types of body waves are recognized: compressional waves and shear waves. Compressional waves have higher velocities and will arrive at any given point prior to shear waves. The concern here is that compressional seismic waves will be propagated from the earth into waterbodies. Surface waves are usually produced when a body wave travels to the surface and is reflected back. Surface waves contribute to production of ground vibrations that are of concern to incubating fish eggs.

Underwater shock waves resulting in sudden changes of hydrostatic pressure may result in trauma and death of fish. This would be expected of strong shock waves resulting from a blast in close proximity to fish. Injuries may range from ruptured internal organs to scale loss. Potentially lethal injuries include the rupture of the swim bladder and rupture and haemorrhage of the kidney, liver, spleen, gonads, and sinus venosus (Wright, 1982). Other injuries resulting from shock waves include ribs torn loose from the body wall, torn adipose tissue, and ruptured blood vessels in the body wall (Wright, 1982). Fatalities are caused either directly by trauma or indirectly through loss of equilibrium resulting in increased predation or inability to feed.

The susceptibility of fish to pressure change is dependent upon orientation with respect to the wavefront, body shape, body size, and presence or absence of a swim bladder (Wright, 1982; Yelverton et al., 1975). The impulse required to cause mortality increases considerably with body weight and thus smaller fish are more likely to be injured than the larger fish.

Larval stages of fish do not develop a swim bladder until they have absorbed the yolk sac and emerged. Therefore, they are fairly resistant to rapid pressure changes

(Bishai, 1961). However, the eggs and embryos of salmonids and other fish are particularly sensitive to shock or agitation. The sensitivity varies with the stage of development (Smirnov, 1954; 1955). There is a high degree of sensitivity to shock and vibration until the eggs reach the eyed stage. Damage to the eggs and developing embryos consist of deformation and compression of the membrane, spinal curling of the embryo, displacement of the embryo and disruption of the vitelline membrane (Wright, 1982).

An explosive impact model was used to determine the potential impacts of blasting on fish populations in streams adjacent to the Restigouche deposit. The minimum set-back distance from the stream when using a 20.9 kg charge in waste rock has been estimated to be approximately 106 m for fish weighing 100 gm (1% mortality). The model predicts the theoretical lethal range of buried charges, but assumes that the substrate is homogeneous to the edge of the water. If the substrate is not homogeneous (i.e. unconsolidated material over bedrock) it is expected that much more of the energy would be attenuated and thus the lethal range would be decreased from the value predicted (D. Wright, DFO, Winnipeg, personal communication, 1989). The substrate along Charlotte Brook is known to be heterogeneous. The bedrock is overlain by approximately 1 metre of overburden and, therefore, the lethal range would be decreased due to attenuation of the energy from a blast.

The Alaska Department of Fish and Game is developing blasting guidelines covering the set-back from a stream edge necessary to protect salmonids. In their proposed guidelines, they recommend a set-back in the range of 60 to 122 m for a charge weight between 11 and 45 kg (D. Wright, DFO Winnipeg, personal communication, 1989).

6.2.1.1 Proposed Mitigation and Residual Effects on Aquatic Resources

Several mitigative measures may be employed to reduce the effects of buried charges. Those considered appropriate for the Restigouche property are described below (Munday et al., 1986):

1. The development of a carefully planned blasting program to minimize the size of charges and the total number of charges required.

2. The use of detonating caps with built-in time delays to reduce the effective charge per delay period.

3. Decking the charge which subdivides the charge in one drill hole into a series of explosives.

4. Use of non-propagating explosives.

5. Use of two caps to detonate each charge to ensure detonation as planned without cap failure.

6. Overdrilling the holes to ensure proper fracturing of the substrate.

7. Use of gravel or similar substrate to stem holes (i.e., filling the holes to the substrate surface level after the charge is in place).

The effectiveness of these measures is dependent on several site-specific characteristics. Discrepancies between effects predicted and those observed under actual field conditions may be expected when blasting adjacent to waterbodies where soil conditions, the geometry between the blast source and the waterbody, and the soil-water interface act to attenuate, reflect, and refract shock waves.

A field monitoring program will, therefore, be undertaken to determine safe blasting practices to protect aquatic life. The resident fish population will be temporarily removed for a distance 100 metres upstream and downstream of the initial blasting area and instream barriers will be installed to prevent fish from returning prematurely. Several fish will be placed in cages adjacent to the blast site for observation purposes. The fish barriers will be removed after development of compatible blasting procedures. The diversion facilities for the north branch of Charlotte Brook will be located a minimum of 60 metres from the western perimeter of the open pit to protect aquatic life.

Monitoring will also be conducted to determine if residual blasting compounds occur in the effluent. Nitrate will be monitored (see Section 8.3) and if found to exceed acceptable limits, the water will be treated for its removal. No residual effects are expected.

6.2.2 Potential Effects on Material Adjacent to Pit

Blasting with high-strength charges at the final pit limit could potentially cause over-fracturing of sulphide-bearing material adjacent to the pit wall. This could affect rock permeability resulting in increased infiltration of groundwater into the pit, influencing potential acid generation from the pit walls.

6.2.2.1 Proposed Mitigation and Residual Effects on Material Adjacent to Pit

Upon reaching the outer pit limit, blasting techniques will be modified to prevent over-fracture of material beyond the final pit wall face. This involves a smooth-blasting technique in which the positioning of the charge is modified and the strength of the charge is reduced. The result is a final pit wall with very little fracturing, allowing the wall to maintain its integrity to prevent crumbling.

The negligible fracturing in the final pit wall will not increase rock permeability and therefore not affect groundwater infiltration. No residual effects are expected.

6.3 Potential Effects of Stream Diversion on the Groundwater System

The proposed mining development will involve permanent diversion of the north branch of Charlotte Brook into the south branch as shown in Figure 3-2. The excavation will commence some 20 m north of the brook at elevation 410, and will then be extended northwards and deepened to elevation 350 metres or as required for recovery of the massive sulphides. Assuming that surface water is effectively redirected, water will enter the excavation by two means; as precipitation and through the fracture system of the bedrock as groundwater.

The diversion facilities for the north branch of Charlotte Brook will be located a minimum of 60 metres from the western perimeter of the open pit to protect aquatic life.

The mean annual precipitation in the area is approximately 1025 mm. For a mine area of 5 hectares, annual precipitation would therefore result in a little over 50,000 cubic metres of inflow, equivalent to a sustained rate of 0.0016 cubic metres per second. The maximum and minimum annual precipitation rates (and therefore this component of the mine inflow) would be approximately 145 and 75 percent of the above mean value, respectively.

Groundwater flow into the mine excavation would include that water which recharges the groundwater system north of Charlotte Brook, and also that water which will locally recharge the bedrock at the brook diversion itself when the hydraulic gradient is reversed by mine dewatering.

The magnitude of the first, "northern" component is estimated as follows. Assuming that the potential recharge area to the north is 70 hectares and that a recharge rate of 65 mm is realistic, then infiltration into the mine from this source would be approximately 45,000 cubic metres per annum, corresponding to 0.0015 cubic metres per second. Groundwater entering the bedrock system beyond the influence of the mine would discharge into Charlotte Brook, as before, thereby rejoining the surface water system before reaching the minesite.

When the water level in the mine area is lowered below brook level, Charlotte Brook and/or its diversion will act as a line source, locally recharging the groundwater system and thereby contributing to the "southern" component of groundwater entry into the open pit. The rate of such groundwater flow will depend on the hydraulic gradient and therefore on the distance of the brook diversion from the edge of the mine. For separation distances of 10, 50 and 100 metres, the estimated inflow from the "southern" component is 0.03, 0.006 and 0.003 cubic metres per second, respectively. These estimates are based on an average bedrock hydraulic conductivity of 1.5×10^{-4} cm/s. The actual average hydraulic conductivity may prove to be lower than this, causing these inflow estimates to be on the high side, but nevertheless most of the water entering the excavation is likely to be groundwater entering from the south side, of which approximately one quarter (0.0015 m^3/s at the 50 metre separation distance) would be from the brook itself. The summer, spring and annual mean flow rates for Charlotte Brook are estimated to be 0.05, 0.5 and 0.1 m^3/s, respectively (see Section 4.2.1).

The dewatering activity would result in groundwater flows towards and into the excavation. This water will be pumped out and treated. Contamination of waters within adjacent rock units will not occur.

6.3.1 Proposed Mitigation and Residual Effects

Although theoretically not required, the diversion channel will be lined to reduce the possibility of the stream drying up at times of low flow due to leakage into the pit. Inflow to the open pit will be treated prior to discharge. No residual effects on groundwater resources are expected.

6.4 Ore Trucking

Ore mined from the open pit will be loaded into 35 tonne capacity off-highway trucks for transfer to the ore dump station at the northern end of the minesite. The ore will then be loaded from the dump station into 25 tonne capacity highway trailers for transfer to the off-site mill.

A fleet of four trucks will be required for the ore transfer, of which one will be a spare. The fleet will operate on three 8 hour shifts per day. On the assumption that 750 tonnes per day will be mined and the effective capacity of the 25 tonne trucks will be 21 tonnes, there will be 36 truck movements per day, or 12 per 8 hour shift.

6.4.1 Transportation Spills

Accidents during the haulage of ore could result in spillage of ore onto roads, adjacent land or watercourses. Spills could pose a risk to the aquatic environment if the ore is in an active acid generating condition and clean-up measures are not implemented.

6.4.1.1 Proposed Mitigation and Residual Effects

In all such situations, the local police, Department of Transportation and the Department of the Environment will be immediately notified. Clean-up measures will be immediately undertaken by Marshall site personnel. If the ore has a tendency to oxidize shortly after excavation from the ore body, lime will be added at the site to inhibit initiation of the acid generation process. This will eliminate the potential for environmental risks during haulage. The removal of any spills from water courses will be followed by restoration of any damaged habitat to meet requirements of the DNRE.

6.5 Operation Interruption

6.5.1 Systems Failure

Failure of the various control systems could occur as the result of any one of or combination of events. Events could include those such as:

1. storm precipitation or runoff in excess of the design storm;

2. breaching or overflow of the various control ditches and ponds;

3. an accidental or improper action by operators at the minesite leading to a spill of untreated or inadequately treated water;

4. failure of one or more items of the mechanical treatment equipment resulting in an overflow from the system, and

5. accidental overflow or spill of reagents and other materials used in the mining operation (i.e. explosives, lubricants and fuels).

6.5.1.1 Proposed Mitigation and Residual Effects on the Terrestrial Environment

As noted in earlier sections, the development would be designed to ensure that all accidental spills or overflows from the control system for acidic drainages would enter the open pit (items 1, 2, 3 and 4). Spills of other solid and liquid materials (item 5) at the site would be immediately contained to ensure minimal effects on the local environment. Failure of the control systems would have limited effects on the terrestrial environment.

6.5.1.2 Proposed Mitigation and Residual Effects on Aquatic Environment

The drainage control system will be designed to ensure that any accidental overflows or spills enter the open pit. The failure of the systems for the control of acidic drainages will have no direct effect on the aquatic environment.

Failure of the control systems would also be considered to have occurred if the quality of the treated water does not meet the objectives defined in Table 6-4. These effluent limits would ensure that the quality of water in Charlotte Brook remains adequate to protect the aquatic habitat under low stream flow conditions. Mitigation methods to ensure adequate quality will include a treatment system which is designed and operated to meet these limits, and monitoring of the effluent to ensure acceptable quality. Continuous monitoring of the effluent will be undertaken to determine if additional measures are required. Mitigative measures include automatically stopping discharges or diverting them into the openpit if "off-specification" conditions occur.

6.5.2 Loss of Milling Support

Two scenarios exist in considering a loss of milling support. Milling support could be lost for a number of reasons which would result in a temporary interruption (i.e. strike at mill, milling equipment failure, etc.). The other possibility would be the permanent loss of milling support.

Marshall would respond to the interruption based on the particular situation. If the interruption were of a temporary nature the mining operations would continue as usual until the ore storage pads at the milling facility and at the minesite were full. Following this, the ore movement would cease and the treatment system would be maintained. Upon resumption of milling support, the ore movement would also resume.

If the loss of milling support were permanent Marshall would consider possible alternatives and advise/consult with the Province. If milling support could not be replaced the reclamation plan would be implemented.

6.6 Socio-Economic Effects

6.6.1 Employment Considerations

A total of 55 persons will be directly employed in the mining of Restigouche ore and the haulage of it to the off-site mill. At the Caribou mill, for instance, the full crew of 39 will be required to process the ore, but they will be dedicated to Restigouche ore for only approximately 30% of their time; thus 12 "net" people can be considered to be fully employed on Restigouche ore in the mill. The total direct employment resulting from the Restigouche operation will therefore be 67 people.

For mining and milling operations such as that proposed at Restigouche there is a "multiplier effect" upon the local and regional workforce. This is an expression of the impact of the project upon the livelihoods of off-site suppliers and tradespeople. Industry experience (C. Smith, East West Minerals Ltd., personal communication, 1989) has shown that the multiplier will most likely fall in the range 3-5, and for the purposes of this report the figure of 4 has been used. This implies that a total of 268 employees, suppliers and tradespeople will derive economic benefit from a mine at Restigouche.

The life of the presently known open-pittable ore reserve at Restigouche is approximately 4 years. There will, therefore, be approximately 268 person-years of direct employment resulting from development of Restigouche, and approximately 1072 person-years of economic benefit derived from it.

6.6.2 Operations and Maintenance Expenditures

As part of the process of completion of the feasibility study, Marshall is detailing and refining its estimates of operations and maintenance expenditures. Based on the existing preliminary work, the operating costs at Restigouche are estimated to be approximately $27.50/tonne (see Section 3.5.2). Using figures derived from the Caribou operation, Marshall believes that the direct cost of milling ore will be approximately $11/tonne exclusive of fixed costs. Total cash costs of $38.50/tonne are therefore estimated for mining, transport and processing of Restigouche ore.

On an annual basis, the operations and maintenance costs for the range of 700-1050 tpd of ore production will be between $9.24 million and $13.86 million. If one million tonnes are extracted over the projected life of the operation this will translate to a total of approximately $38.5 million for operations and maintenance costs.

6.6.3 Economic Effects

Most of the operations and maintenance expenditures incurred on Restigouche ore would remain in the local and Provincial economy. The largest single proportion of these expenditures would be the direct labour costs, and the Province would benefit from income and sales taxes paid on labour and supplies as well as the royalty, income and mining taxes levied upon the operation.

For purposes of preliminary estimation, it has been assumed that up to 50 percent of operations and maintenance expenditures are direct labour costs (Kilpatrick, Micon, personal communication, 1989). On the same basis as the previous section, the annual payroll attributable to the mining and processing of Restigouche ore is estimated to lie between $4.62 million and $6.93 million. Over the life of the operation the total payroll will be approximately $19.25 million. Assuming an overall 25% income tax rate, the direct revenue to the Province from the payroll related to Restigouche would be between $1.16 million and $1.73 million per year. Over the project life the total would be approximately $4.8 million.

It is estimated that a total of approximately $10.2 million will be spent over the life of the operation on capital items, of which some $9.4 million is expected to be spent before the end of 1990. While it is not yet possible to estimate the local impact accurately, Marshall expects that a substantial proportion of these expenditures will be made in New Brunswick.

Assuming July 1989 metal prices, but dependent upon final selection of processing options and detailed examination of the tax rules, the mining tax, income tax and royalty received by New Brunswick directly from the Restigouche operation is estimated to total between $1.35 million and $2.03 million per year. Over the project life these would total approximately $5.4 million.

Adding employee income taxes, project income taxes, mining taxes and royalties together yields estimated total direct revenues to the Province from the Restigouche project of between $2.51 million and $3.75 million per year. Over the project life these would total approximately $10.2 million.

6.7 Cumulative Effects

The Upsalquitch watershed has relatively little industrial development. The major industry is forest harvesting (G. Godin, NBDNRE, personal communication, 1990). The New Brunswick International Paper Company (NBIP) has acquired 25 year leases on the Crown Land watershed for timber harvesting. The area of the mine is not currently being harvested. Cutting plans have been developed for the 1992 - 1997 period, however, including the Mount Brittain area around Charlotte Brook and the minesite (see Figure 4-1). Activities which could affect the Upsalquitch drainage in relation to forest harvesting include land clearing, forest road construction and material transport.

Timber harvesting and road construction, may result in increased siltation in Charlotte Brook due to increased surface runoff and sediment load, decreased bank stabilization and decreased water velocity due to accumulation of instream debris.

Increased stream siltation may be detrimental to fish health and fish habitat as it may damage gills and cover available habitat with fine sediment. Fish habitat could be further damaged by a decrease in streamside vegetation as a result of timber harvesting, which may decrease available cover, increase instream water temperature, and decrease the supply of invertebrates available as food for fish.

Impacts on Charlotte Brook as a result of planned timber harvesting operations can be limited by leaving a minimum vegetated buffer zone of 15 m along the stream bank. Proper bridge construction, culvert installation and roadside bank stabilization can decrease negative effects on the water course. Piling of slash and debris away from stream banks and not operating heavy machinery beside or in a stream will further eliminate detrimental impacts on fish habitat.

Runoff from the proposed minesite will be controlled and treated. Construction activities near and in watercourses will follow approved procedures. Therefore, through adherence to proper and approved operating practices, no cumulative effects on the aquatic environment are anticipated from mining and forest operations.

The softwood stands on and around the minesite which are proposed to be harvested, are not part of the stands used by local deer populations as wintering areas. These softwood stands are presently surrounded primarily by intolerant hardwood dominated stands. It is expected that the removal of the standing softwood would favour hardwood regrowth and thereby increase food availability for deer in the short-term following the cutting. This may provide deer with access to good quality forage prior to yarding, resulting in deer entering the wintering area in good physical condition. The cut areas proximate to the deer wintering area may also provide accessible forage during winter.

Increasing the amount of open forest areas due to cutting would likely increase deer visibility and provide additional hunter access to adjacent areas. This would favour the deer harvest in the area.

Increased traffic in the area due to mining and forest cutting operations may result in increased vehicular collision with deer during certain periods. This is not expected to increase to an extent that would be detrimental to the population.

Both mining and forest harvesting activities will create noise and the removal of forest cover around the mine will allow the noise to travel further. However, due to the surrounding terrain, the period over which cutting will occur, and actual cutting pattern proposed, the mine-related noise is not expected to have adverse effects on deer wintering in the area.

The only other industrial development within the boundary of the watershed is the Murray Brook mine, owned and operated by NovaGold Resources Inc. The mine is located within the Southeast Upsalquitch River drainage and has been in operation since mid-1989. The mining-milling facility utilizes a closed-loop cyanide gold extraction process, which is non-water-consumptive. Extraction reagents (i.e. cyanide and mercury) are reclaimed throughout the system and re-used in further gold extraction processes. The cyanide reclamation process, for instance, reclaims 98% of cyanide used (P. Pheeney, Sub Surface Surveys, personal communication, 1990). Due to the nature of the gold extraction procedure, no mine effluents have been released into the aquatic environment. It is anticipated that potential future effluents may contain suspended solids which would be treated prior to discharge (P. Pheeney, Sub Surface Surveys, personal communication, 1990). Therefore, no cumulative effects are anticipated due to the operation of the two mining facilities.

As indicated above, the activities in the Upsalquitch watershed which could potentially affect the system, are two mining operations and forest harvesting. Cumulative impacts on the aquatic environment and local wildlife populations are expected to be minimal.

7.0 ENVIRONMENTAL IMPACT ASSESSMENT - POST OPERATION

This section of the report assesses the effect of mine closure on the biophysical and socio-economic environments. Environmental concerns include the effectiveness of reclamation measures and the socio-economic effects of mine closure.

7.1 Reclamation

The proposed reclamation measures (Section 3.4) are designed to enable complete abandonment of the site without further obligations to Marshall or the Province. After reclamation and flooding of the pit, groundwater combined with surface runoff will continue to discharge into the pit and Charlotte Brook.

7.1.1 Reclamation Measures

Surface runoff includes discharges from the reclaimed, vegetated areas. Sulphide bearing waste rock and demineralized sludge from the treatment process will be placed in the bottom of the open pit and covered with overburden to control oxygen diffusion. The pit will then be flooded. Exposed sulphides in the pit walls above the flooded water level will be graded and covered with material of very low permeability and then vegetated.

7.1.1.1 Flooding of Sulphides

Estimates of acid generation rates for the flooded sulphides indicate that less than 2 mg of acidity (as $CaCO_3$) will be generated per litre of water which overflows the pit into Charlotte Brook, during low flow conditions. This negligible quantity of acidity (equivalent to a sulphate increase in the water of less than 2 mg/l) will have no effect on water in the pit or in Charlotte Brook. The estimates were based on the extent of flooded and sealed sulphides, the type of cover (flooded or clay-type seal), the presence of the diffusion barrier to the transport of atmospheric oxygen, values for diffusion coefficients and permeabilities, and an assumption of low flow runoff conditions to ensure a worst-case situation.

Groundwater and surface water quality is very good with pH values exceeding 7, and relatively high alkalinity (a measure of buffering capacity of water against changes in pH; refer to Sections 3.2.1, 4.1.4.3 and 4.2.1.1). The buffering capacity of groundwater and surface water conservatively were not included when estimates of acid generation rates were calculated. The negligible quantity of acidity produced (2 mg/l as $CaCO_3$) by the waste rock after reclamation will be offset by inflow of alkaline water.

The results of the estimates of acid generation are consistent with observations at other properly flooded sulphide deposits which show practically no generation of acidity (Monenco Ltd., 1984). The effectiveness of underwater impoundment of high sulphur base metal tailings was determined by a study of the tailings area associated with the Mandy Mine in Flin Flon, Manitoba. After 32 years of underwater impoundment, the high iron (17%) and sulphur (15-17%) content material has oxidized very little. With no expenditures on site maintenance or rehabilitation, water quality is good and aquatic fauna and insect life has reinhabited the tailings area. Vegetation has recolonized the area and produced a covering of organic matter over the surface area of the tailings (Hamilton and Fraser, 1978).

Cominco operated a mine at Benson Lake on Vancouver Island from 1963 to its closure in 1973. Approximately 2.1 million tonnes of tailings containing pyrrhotite (4%), pyrite (0.5%) and copper (0.1%) were deposited in the lake. A study conducted by Environment Canada in late 1973 indicated that no significant degree of oxidation had occurred in the tailings. It was found that lake conditions were satisfactory to support aquatic life. The study also concluded that the heavy metals found in the tailings solids were essentially fixed and not being assimilated in the biological food chain. In contrast to this, other tailings, which were deposited on the surface near the mine site, showed evidence of sulphide oxidation and "extreme acidity".

At the Bluebell Mine in British Columbia, approximately 1.5 million tonnes of acid generating sulphide tailings (assayed at about 0.4% lead, 0.5% zinc and 24% iron) were deposited in Kootenay Lake from 1952-1971. Prior to this operation (1908-1921), approximately 500,000 tonnes of jig tailings (assayed at about 1.5% lead, 5% zinc and 33% iron) were deposited in the lake. Recent metallurgical test work on zinc-rich samples of the tailings indicate that oxidation has not occurred. This is consistent with the fact that flooding of sulphide-rich tailings has been found to provide an effective barrier to the transport rate of oxygen into the tailings (Ohio State, 1971).

All studies that have been carried out on underwater impoundment to date in Canada have been related to high acid generating tailings. Tailings consist of finely ground solids containing host rock, ferrous sulphides (pyrite, arsenopyrite, pyrrhotite, etc.) and at least traces of other base metal sulphides. The tailings may contain from only a few per cent to over 70% of pyrite and other sulphides (Monenco Ltd., 1984) The "footwall" rock which is to be disposed of in the Restigouche pit following closure contains as much as 10% weight sulphides. This waste rock has substantially less acid generating potential than tailings.

7.1.1.2 Exposed Sulphides in Pit Wall

The east pit wall will be sloped to allow establishment of a stable cover. Standard reclamation practices for pit walls and storage piles have been established by two provinces and are considered essential for all mine abandonment (British Columbia Ministry of Energy, Mines and Petroleum Resources, 1979 and Alberta Land Conservation and Reclamation Council, 1977). Recommended procedures are intended to:

(i) stabilize erodible slopes;
(ii) control dust;

(iii) maximize aesthetic value;

(iv) maximize evapotranspiration to minimize runoff;

(v) facilitate crop production; and

(vi) reduce oxidation to reduce potential acid mine drainage (Williams, 1975).

In preparing the minesite to facilitate reclamation, the process varies greatly from major earth moving and landscaping (backfilling, terracing, and contouring) to seedbed preparation (ripping, grading, ploughing, and harrowing), each for a specific purpose.

Typical site preparations include:

(i) contouring slopes in backfilled sites;

(ii) burying or eliminating any physical inhibitors to plant growth;

(iii) covering barren disturbed areas with previously stored topsoil, subsoil, or overburden. Sufficient stock piles of soil and overburden is available;

(iv) ripping the surface may be necessary due to compaction from large machinery used in backfilling and contouring. Ripping breaks up the surface and allows root penetration and improved water infiltration, reduces runoff, and aids in the integration of material cappings or subsoils with underlying wastes, as well as preventing or reducing slippage and erosion;

(v) grading and levelling of top-dressed areas in order to prevent excessive runoff and erosion (Hubbard and Bell, 1977); and

(vi) seedbed preparation, including ploughing, discing and harrowing.

Establishment of a stable slope is critical to successful reclamation. Past reclamation programs for coal mines in the Minto - Chipman region of New Brunswick have met with varying degrees of success. Most of the area was not graded and steep slopes remained (up to 84% slope), resulting in serious slumping and loss of planted areas (Montreal Engineering Company Ltd., 1978).

In British Columbia reclamation guidelines for coal mines require waste dump faces to be resloped to an angle of 26°. In 1977, Fording Coal Ltd. initiated field tests to investigate optimal resloping techniques to be used in reclaiming their waste dumps. The objective of the slope study was to see if it could be demonstrated that steeper angles could be successfully reclaimed. The benefits being reduced material movement and less surface area to be reclaimed, and hence cost savings (Berdusco and Popowich, 1979). Additional studies were designed to compare vegetation growth on bare waste rock with bare rock capped with glacial till. Earlier investigations in the Crowsnest Pass indicated that the biological angle of repose lies between 25° to 30° which is 7° to 12° less than the physical angle of repose (Harrison, 1974). At elevations of 1,700 metres Fording resloped waste dumps with slopes of 37° to slopes ranging from 24° to 34° with various aspects. Calcareous glacial till layers, 15 to 30 centimetres thick were placed over portions of the wastes at angles of 26°, 28° and 30°, and then hydroseeded with a grass-legume mixture.

Preliminary results indicated that operationally, waste dumps could be worked from 28° to 30°, but slopes from 30° to 34° resulted in cross pushing with low productivity and deep track markings. On slope angles between 32° to 34° small circular failures occurred on isolated areas of fine wet materials. Glacial till eroded readily and large amounts of fines collected at the toe of 26°, 28° and 30° slopes (Marshall, 1983).

7.1.2 Proposed Mitigation and Residual Effects

As noted above, studies have shown that little or no oxidation occurs to sulphide-rich tailings when disposed of in underwater impoundments. Marshall, therefore, proposes to transfer all stored sulphide-bearing waste rock along with any iron-gypsum sludge to the bottom of the open pit. The potentially acid generating rock and sludge will be spread evenly over the bottom of the pit, then covered with overburden of low permeability to create, when flooded, a diffusion control barrier between the waste material and pit water. This additional barrier will ultimately eliminate acid generation in the sulphide waste rock. Capping exposed sulphide-bearing rock above the water line will effectively eliminate the continued generation of acid from these sources. The reclamation program has been designed to ensure that the site can be abandoned without the need for continued collection and treatment of residual drainages.

The gypsum-rich sludge could potentially release metals which could result in deterioration of water quality within the flooded pit. If tests of the sludge confirm this potential, metals will be removed from the sludge prior to disposal (see Section 3.2.3).

As discussed in Section 3.4, the reclaimed site will consist of a contoured and revegetated waste rock dump, and a flooded pit. These features would not significantly detract from the aesthetic features of this relatively remote region of New Brunswick.

If exposed sulphides remain in the east pit wall, the following reclamation procedures will be conducted to ensure long-term slope stability:

(i) The pit wall will be sloped to 2.5:1 (approximately 22°) to ensure cover stability.

(ii) The pit wall will be excavated an additional 1 metre below the pit flood level of 410 m. The shoreline area will be rip-rapped (utilizing non-acid generating waste rock) to protect against erosion due to wave action.

(iii) Soil and glacial till stored on-site will be used to cover the pit wall. A cover ranging in depth from 30 cm to 45 cm is recommended for better vegetative survival rates. A gravel layer will be placed between the sulphide materials and overburden to interrupt capillary flow and prevent acidic contamination of overburden.

(iv) Wherever possible, equipment will travel across the slope to reduce the rill and washouts from precipitation until vegetation is sufficiently established to prevent erosion.

(v) Following slope preparation, it will be hydroseeded with a combination of fertilizer, mulch and grass seed. The mulch will provide shade and reduce moisture loss, thus increasing the survival rate of the young seedlings.

Based on current estimates, considering annual precipitation and groundwater inflow, the pit will require approximately 2 years to flood if left to fill naturally. It is desirable to flood the pit as quickly as possible to reduce the potential for oxidizing sulphide-bearing materials, thus minimizing acid generation, and to prevent erosion of the diffusion layer. It is possible to expedite flooding by diverting water from Charlotte Brook into the pit. A stop-log structure will be placed in the brook upstream of the site and operated to divert flows exceeding 25% of the mean annual flow to the pit. This will reduce the flooding time substantially. Once the pit has been flooded, the flow from Charlotte Brook will be stopped and water quality in the pit will be monitored to determine when it has stabilized at an acceptable level. Details of the conceptual plan will be provided in the finalized Reclamation Plan and discussed with the appropriate regulatory agencies.

The level of water in the pit will stabilize at the level of Charlotte Brook. Groundwater discharge to the disturbed area and hence to Charlotte Brook will continue indefinitely. Although groundwater dissolved oxygen concentrations were not determined for the site, it is believed that these levels are well below those that will exist in standing water in the flooded pit. Therefore, this is not expected to be a source of oxygenation for sulphide-bearing materials. The annual volume of groundwater discharge occurring via the disturbed zone is probably less than 1% of the total average Charlotte Brook flow and perhaps 5% at low flow periods.

Access to the flooded pit will be from the south and east sides of the pit. The north end presents a potential safety concern. The pit crest will be modified to ensure that the approach to the highwall is clearly visible. Appropriate signs will also be posted.

The facilities for the collection and treatment of acidic drainages will remain in operation or on a standby basis during a three year period of monitoring to ensure that the site can be abandoned. Marshall has confirmed that they will accept full responsibility for reclamation, the subsequent monitoring program, maintenance of the treatment system, and for satisfying the regulatory agencies that the site can be permanently abandoned.

7.1.3 Proposed Fisheries Management Program

Marshall recognizes that the abandoned pit will offer opportunities for fisheries management and will ensure that the pond is capable of supporting fish life upon abandonment. Recreational fisheries have previously been successfully developed in abandoned strip mine ponds in New Brunswick. For example, strip mine ponds in the Minto area, many of which have similar depth profiles to the proposed pit after abandonment, have excellent year-round water quality due to the complete absence of oxygen consuming organic material in their benthic regions (W. Hooper, DNRE, personal communication, 1989).

The water quality of the flooded pit (pond) at Restigouche is expected to be very good with a similar chemical composition to the north branch of Charlotte Brook. There will be no organic material in the pond to deplete dissolved oxygen levels. The water quality in Charlotte Brook is very good with an alkalinity of approximately 34 - 39 mg/l. Natural productivity in the pond will probably be limited by its extreme depth (25 metres), lack of littoral area, and small surface area (approximately 5 ha).

An approximation of potential sport fish production was made using Ryder's morphoedaphic index (MEI) calculation (Ryder, 1965). A mean depth of 75 feet (maximum depth will be 25 metres, and the bottom will be virtually flat) was assumed. A total dissolved solids (TDS) level of 55 ppm was estimated by transforming alkalinity measurements of Charlotte Brook immediately downstream of the confluence of the north and south branches using a calculation by Ayer (DNRE, personal communication, 1989). The MEI was calculated (TDS/mean depth) to be 0.73. Potential fish production was calculated (Y=2* sqrt MEI) to be 1.8 lb. per acre or approximately 10 kg (22 lb.). There will be no competitive species in the pond. Therefore, the calculated production value represents the estimate of annual sport fish production from the pond.

The production estimate represents 44 adequately sized brook trout (230 g; 1/2 lb each). This represents approximately 20 angler days, and therefore fisheries management at great expense is not warranted. The area is too remote to justify put and take stocking of brook trout for an ice fishery. A wild, self-sustaining brook trout population will exist only if the pond is reconnected with Charlotte Brook because spawning habitat for trout in the pond will be inadequate. There is little likelihood of successfully establishing brook trout spawning in the pond. Shallow water, adequately sized gravel, and upwelling groundwater flow is required (Witzel & McCrimmon, 1983). Brook trout are usually very dependent on production from the littoral region (Speirs, 1974) which will be virtually non-existent in the proposed waterbody. However, trout will assume a pelagic (open water, away from the lake bottom) existence if a suitable forage fish is present.

The recommended course of action is to stock landlocked smelt while the pit is remote from the brook. While the pit is flooding, a small artificial reef of boulders and cobbles should be established along the access road to the pit bottom. Within two years, if the water quality of the pond proves to be adequate, the brook should be rerouted through the pond. Brook trout will gain access to the pond, where they will feed on smelt. The reef will provide spawning habitat for smelt, brook trout will recruit from Charlotte Brook, and a self-sustaining fishery will have been established. No subsequent management intervention will be required. To maintain angling pressure at the level which the pond will support, road access to the site should be restricted.

7.1.4 Proposed Monitoring Program

Monitoring will be conducted following reclamation to ensure that the site can be abandoned. The program will include the monitoring of water quality at sites upstream in the north and south branches of Charlotte Brook, water quality in the flooded pit, water quality in Charlotte Brook downstream of the minesite, and in the Upsalquitch River just below the lake. Monitoring of the benthic community and fish populations at these sites will also be continued.

Water quality monitoring conducted upstream in Charlotte Brook will provide data for comparison of quality in areas above the influence of the site, with that from various locations which are subject to site influence. Any effects the flooded pit may have on the quality of receiving waters will be determined. Also, within the flooded pit itself, water samples will be collected to determine if oxidation of the disposed material occurs following reclamation.

Any significant changes in water quality may be reflected in populations of aquatic biota. The establishment of fish populations in the flooded pit will provide visible evidence of adequate water quality. The proposed fishery management program will provide valuable input to the monitoring program.

Aspects of the proposed monitoring program are described in Chapter 8. The type of sampling and schedule are summarized in Table 8-1.

7.2 Socio-Economic Effects

It is proposed that after mining and reclamation, several permanent features would remain in the vicinity of the minesite. These features would include the flooded pit, an inert waste rock pile and approximately 4 km of haulage road. These features would involve a total surface area of 20 - 25 ha. The Restigouche operation will, therefore, result in the permanent removal of up to 25 ha of productive forest land from the Upsalquitch Licence. Considering the current area of productive forest land included in the licence (366,000 ha) it is reasonable to assume that the loss of 25 ha would be of little significance.

With respect to the dollar value of wood fibre that would be lost as a result of the loss of 25 ha of forest land, the following estimates were provided by DNRE Timber Management Branch. The permanently disturbed area has a predominantly hardwood forest cover (which has a negligible current market value). However, it is estimated that approximately 18 ha has a significant softwood (spruce and balsam fir) component that has the potential to produce up to 50 m^3 of softwood pulpwood per hectare during a rotational period of approximately 50 years. This pulpwood would have a current stumpage value of \$8.86/m^3, or approximately \$400/ha. The total disturbed area would therefore have a potential wood value of \$7200 or \$144/yr (Frame, DNRE, personal communication, 1989).

Approximately 415,000 m^3 (Frame, DNRE, personal communication, 1989) of softwood are harvested annually from the Upsalquitch Licence. Considering the above wood volume and value in light of this, it seems reasonable to assume that the loss of 25 ha of forest land would not significantly affect the operation of the Upsalquitch Licence.

7.2.1 Employment Considerations

Upon exhaustion of the Restigouche ore reserve mining, transport and milling will cease. All staff positions, other than those required to perform the necessary reclamation work, will be terminated. It is currently estimated that the reclamation work, involving transfer of potentially acid generating waste to the pit bottom and covering it with overburden, recontouring and placement of soil cover on the inert waste rock pile and recontouring and seeding of the disturbed area will take approximately six months.

The employment considerations relating to reclamation are believed to be minimal compared to those effective under full operation. Marshall has therefore not specifically estimated these for the post-operation period.

7.2.2 Social Effects

Upon the cessation of mining activity at Restigouche the income streams to the local and Provincial areas will stop. Employees released from the operation will either seek mining work elsewhere or return to their previous occupations.

The area disturbed by the mining activity will return to its traditional consumptive and non-consumptive uses. These include fishing, hunting, trapping, forestry, hiking and camping.

8.0 PROPOSED MONITORING PROGRAM

8.1 Introduction

Monitoring involves the collection of a series of repeated measurements over time. Monitoring of the various phases of major capital projects may be categorized as compliance monitoring or environmental effects monitoring.

8.2 Compliance Monitoring

Compliance monitoring is undertaken by a proponent to ensure that regulated levels of parameters in discharges are met. Specific conditions will be described in the Approvals to Construct and Operate which are issued under the Clean Environment Act. The monitoring and reporting schedule normally required, as well as the parameters to be analyzed are, prescribed in the Metal Mining Liquid Effluent Regulations (Environment Canada, 1977).

A complete monitoring program will assure control of the waste management facilities and protection of the environment. Compliance monitoring during the development/construction, operating, reclamation, and post-reclamation phases will be carried out to determine:

1. the quantity and composition of liquid wastewater, specifically acidic drainages from the open pit and sulphide rock pad;

2. the quality of other surface runoff from the site, specifically overflow from the waste rock dump sedimentation pond; and

3. the water quality in Charlotte Brook up and downstream of the mine.

Marshall will provide training to familiarize site personnel with all aspects of the types of monitoring exercises to be undertaken. In addition to the quantitative and routine types of monitoring, referred to above, which are oriented towards protection of the aquatic environment, personnel at the site will be instructed to observe and correct any incidences leading to excessive emissions of dust, noise, or other potential emissions into the environment.

As indicated in Figure 3-2, site discharge will occur at two locations. Accordingly, two sampling stations will be established for compliance monitoring of appropriate parametres. Sites SE-3a and SE-3b will be monitored for discharge of treatment system and sedimentation pond effluents, respectively, into Charlotte Brook (see Table 8-1).

8.3 Environmental Effects Monitoring

Environmental effects monitoring includes monitoring to ensure the accuracy of the effects (impacts) predicted. The proposed program to monitor the waste management operation and to determine any effects of the mining operation on the aquatic

TABLE 8-1

Proposed Monitoring Program

Location	Parameter Group	Monitoring Frequency/ Sample Type	Purpose
AMD-1, AMD-2	A	Twice per month for 6 months, monthly thereafter	quality of acidic drainages
SE-1	A	monthly grab	quality of sedimentation pond overflow
	B	weekly grab	quality of sedimentation pond overflow
SE-2	C	continuous	to activate alarms to stop discharge
	D	weekly composite	compliance monitoring
SE-3 (a+b)	D	weekly composite	compliance monitoring
SE-3a	LC_{50}	quarterly	compliance monitoring
CB-3a	C D	daily grab weekly composite	compliance monitoring effects monitoring
CB-1, CB-2a, CB-3a, CB-4, UR-5, CS**	D	monthly/day composite	effects monitoring
CB-1, CB-2a, CB-3a CB-4, UR-5, CS	macro-invertebrates populations	continuous sampler/assess June, Aug, Nov	effects monitoring
CB-1, CB-2b, CB-3a CB-4, UR-5, CS	fish populations	electrofishing surveys/June Aug, Nov	effects monitoring
CB-2b, CB-3a, CB-4 UL, CS	fish body metal contaminant burden (group D metals)	June, Aug, Nov	effects monitoring
3 wells**	A	monthly/day	effects monitoring
Camps/Deer Wintering Area	noise	monthly	effects monitoring
Flooded Pit	E	quarterly	pit stability

Sample Location[a]

AMD-1 - minewater in open-pit
AMD-2 - drainage from ore/waste rock pad
SE-1 - overflow from sedimentation pond
SE-2 - overflow from treatment system
SE-3a - site discharge (treatment system)
SE-3b - site discharge (sedimentation pond)
CB-1 - South Branch Charlotte Brook - upstream of site discharge
CB-2 - North Branch Charlotte Brook - upstream of site discharge
CB-3a - Charlotte Brook - downstream of site discharge
CB-4 - Charlotte Brook - at Upsalquitch Lake
UR-5 - Southeast Upsalquitch River - at Upsalquitch Lake
CS - Control Site
UL - Upsalquitch Lake

** - Locations to be determined prior to construction phase

[a] - refer to Figure 4-5 for sample locations CB-1 through UR-5

Parameter Group[b]

A - pH, Total Acidity, SO_4, Al, Fe, Mn, Cu, Zn, Pb, As

B - S. solids, Turbidity, pH

C - pH, Turbidity

D - S. Solids, Turbidity, pH, Alkalinity, Ca, Mg, SO_4, Al, Fe, Mn Cu, Zn, Pb, As, Ni, Nitrate

E - pH, Alkalinity, Ca, Mg, SO_4, Al, Fe, Mn Cu, Zn, Pb, As, Ni, D.O.

LC_{50} - effluent toxicity testing

[b] - analyses and detection limits, as per Standard Methods, 17th Edition (AWWA).

and terrestrial environment is summarized in Table 8-1. The program, which will start prior to the construction phase and be continued until the site can be permanently abandoned, will be modified as dictated by the results of monitoring.

Due to general site layout modifications, which were made subsequent to the baseline data collection program, site CB-3 is now inappropriate for monitoring effects below the site discharge. A new station, designated CB-3a, will be established downstream of the proposed sedimentation pond discharge for monitoring effects below the site (see Table 8-1).

Monitoring of environmental effects will be carried out to determine:

1. the state of the aquatic habitat and populations in areas within the influence and outside the influence of the mine;

2. groundwater quality in the vicinity of the mine; and

3. levels of noise emissions at potentially sensitive locations in the vicinity of the mine.

The periodic monitoring of macro-invertebrates and fish populations, within and outside the influence of the mine, will provide an indication of any alterations to the aquatic habitat during the various phases of the project. Benthic invertebrates are sensitive indicators of the health of an aquatic environment. A substantial decrease in invertebrate diversity as computed by the Shannon method (Pielou, 1977) over an annual interval indicates that the aquatic environment has been subjected to stress. Conversely, similar indices of diversity from year-to-year indicate that the environmental conditions are relatively stable. However, an aquatic site undergoes a seasonal cycle of taxa and diversity (Hynes, 1970).

Population statistics will be evaluated for a control site outside of mine influence for determination of natural fluctuations. This information will be used in conjunction with baseline data collected, to determine if population variations are indicative of environmental stress. Where these variations are considered to be indicative of substantial alterations to the aquatic habitat, water quality data from the sampling stations will be analyzed to determine if there are any correlations. This information will be used in designing mitigative measures if required.

Resident fish populations will be sampled periodically to determine levels of body metal contaminant burdens. Sampling will be conducted early in 1990 prior to site development and will continue throughout the subsequent phases until operations are completed. From this, it will be possible to determine the extent of metal accumulation occurring at the top of the aquatic food web. Mitigative measures will be developed if body metal contaminant burdens approach problematic levels.

Noise from the site and associated transportation activities will be monitored at the campsite nearest the mine and at various locations in the Simpson's Field deer wintering area. This will be carried out on a monthly basis using a calibrated hand-held meter. Readings will be taken at several intervals through the day to correspond to known activity levels of the operations. This aspect of the monitoring program will be complemented by an assessment of various sources at the site. The information will be used to determine the accuracy of sound level predictions and to assist in designing mitigative measures as required.

Following site reclamation, monitoring will continue over a three-year period for surface water and groundwater quality. This will include monitoring of water from the flooded pit to determine if sulphide-bearing materials oxidize.

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APPENDIX A

MICON REPORT

micon | mineral industry consultants
INTERNATIONAL LIMITED

ANALYSIS OF THE COST OF MINING THE RESTIGOUCHE DEPOSIT BY UNDERGROUND OR OPEN PIT METHODS

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January 12, 1990.

TABLE OF CONTENTS

Page

INTRODUCTION 1
SUMMARY 3
OPEN PIT MINING 7
  PIT RESERVES 7
  PRODUCTION SCHEDULE 8
  EQUIPMENT REQUIREMENTS AND COSTS . . . 9
  CAPITAL EXPENDITURE 9
    Engineering 10
    Pre-Production Stripping 10
    Mine Equipment 11
    Buildings and Surface Facilities . . . 11
    Contingency 11
    Working Capital 11
  OPERATING COSTS 12
    Drilling 13
    Blasting 13
    Loading 13
    Mine Haulage 13
    Haulage to Concentrator 13
    Site Services 14

Page

Environmental Expense 14
Administration 14
UNDERGROUND MINING 15
RESERVES AND THE SELECTED STOPING METHOD . . 15
General Considerations 15
The Stoping Method 18
PRIMARY MINE DEVELOPMENT LAYOUT AND SCHEDULE . 20
Layout 20
Schedule 21
CAPITAL COSTS 21
Mine Development 22
Mine Equipment 22
Buildings and Services 23
Engineering 23
Contingency 23
Working Capital. 23
OPERATING COSTS 24
POTENTIAL FOR FURTHER DEVELOPMENT . . . 26
CONCLUSION 28

APPENDIX I Operating Cost Estimates pp. (i) to (viii)

LIST OF FIGURES

Following Page

Figure 1 Restigouche Deposit Longitudinal section (schematic) 20

Figure 2 Restigouche Deposit Cross section (schematic) 20

LIST OF TABLES

Following Page

Table I Adjustment to pit quantities 8

Table II Restigouche Property Open pit equipment cost 9

Table III Restigouche Property Open pit services cost estimate 11

Table IV Restigouche Property Estimated direct mine development capital - underground mine 21

INTRODUCTION

Micon International Limited (Micon) was retained by Marshall Minerals Corp. (Marshall) to evaluate the cost of mining the Restigouche lead-zinc deposit in New Brunswick, by both open pit and underground methods. The purpose of the study was to provide an assessment of which mining method might be expected to yield the greater economic benefit.

The current philosophy of development envisages that material mined from the Restigouche property will be processed in an existing lead-zinc concentrator, located some 35 kilometers away. This study makes provision for the cost of hauling ore to the concentrator, but does not include any analysis of processing costs, since these will be the same whether the deposit is mined by open pit or underground methods.

The Restigouche deposit, as presently known, is estimated to contain drill-proven, in situ geological reserves of one million tonnes at an average grade of 7.76 per cent zinc, 6.06 per cent lead, 0.33 per cent copper, 127 grams per tonne silver and 1 gram per tonne gold. The deposit remains open down-plunge, to the north, where more widely spaced drilling has suggested the existence of an additional 600,000 tonnes of material at similar grades.

At present, the mineralization in the down-plunge extension of the Restigouche deposit has not been defined to a level of assurance sufficient to permit the development of plans for mining this material. For this reason, the study presented herein has been confined to an examination of the capital and operating costs involved in mining the current drill-proven reserve by open pit and underground methods. Extraction of the drill-proven reserve by either mining method, however, will not jeopardize the subsequent recovery of any additional ore which may ultimately be demonstrated to exist down-plunge from the current drill-proven reserve.

In undertaking this study, Micon has relied upon geological interpretations, plans, sections and reserve estimates prepared by Neil D. S. Westoll and Associates Limited (Westoll) and upon a computerized block model of the deposit compiled by Roscoe Postle Associates Inc. (Roscoe Postle). Micon has not visited the Restigouche property, nor has it performed any independent sampling of the deposit.

Roscoe Postle has also developed a preliminary open pit layout, together with estimates of the associated capital and operating costs. Micon's assessment of mining the Restigouche deposit by open pit methods is based upon a review of this work. The assessment of mining the deposit by underground methods, on the other hand, is based on layouts and cost estimates developed entirely by Micon.

SUMMARY

The mineralized zone on the Restigouche property outcrops to the south, plunges along strike to the north at about 25 degrees and dips to the west at between 20 and 40 degrees. The principal characteristic of the deposit is that it contains a relatively small tonnage of relatively high grade material.

The deposit could be mined by either open pit or underground techniques.

Generally speaking, open pit mining is a selective technique, capable of extracting the entire ore zone with little dilution from external waste. Underground mining, on the other hand, typically requires that some portions of the ore zone be left unmined in supporting pillars and, also, typically involves a higher level of dilution, with a consequent reduction in net revenue per tonne of ore mined. Under these circumstances, all other things being equal, open pit techniques are preferred.

The cost of open pit mining, however, is heavily influenced by the waste ratio, or the number of tonnes of waste which must be removed per tonne of ore mined. As waste ratio increases, therefore, there comes a point at which the benefits inherent in open pit mining are outweighed by the cost of waste removal. Beyond this point, which is defined by a cut-off waste ratio, underground mining becomes economically justified.

Micon has assessed the extractable drill-proven reserves, the

capital expenditures and the operating costs associated with mining the Restigouche deposit by both open pit and underground techniques. The results of this assessment are summarized below:

	Open Pit	Underground
Mineable reserve (thousand tonnes)	990	800
Capital expenditure ($ thousand)	11,200	12,100
Capital expenditure ($/tonne)	12	15
Mine operating cost ($/tonne)	27	41
	39	56

These data indicate that open pit mining is expected to recover a greater proportion of the in situ, drill-proven reserve and to involve a lower level of both capital expenditure and direct operating cost.

The direct cost of mining material (ore or waste) by open pit methods is estimated at less than $2 per tonne. As shown above, the presently designed open pit, which has a waste ratio of about 6 tonnes of waste per tonne of ore, is estimated to have an operating cost advantage of $14 per tonne of ore, when compared to underground mining. These data imply that open pit mining will continue to be the more economic method until the waste ratio exceeds about 13 tonnes of waste per tonne of ore.

It is to be noted that open pit mining will involve the removal of some sulphide-bearing waste which will have the potential for generating acid run-off. It is planned to store this waste in a separate protected area. Ultimately, however, following completion of mining operations, it may be necessary to return this waste to the worked-out pit, in order to prevent environmental damage. Although precise data are not available, it is estimated that about 15 per cent of the total waste, or one million tonnes, will have acid-generating properties. It is estimated, also, that the cost of returning this material to the pit will be about $2 per tonne. Accordingly, open pit mining may potentially involve an additional expenditure of some $2 million, not included in the estimates presented above.

Such a cost would be equivalent to $2 per tonne of open pit ore, reducing the operating cost margin in favour of open pit mining to about $12 per tonne of ore and reducing the 'cut-off' waste ratio, beyond which underground mining becomes economic, to approximately 12 tonnes of waste per tonne of ore. Clearly, even under these conditions, open pit mining of the current drill-proven reserve remains the preferred method.

While it is emphasized that the estimates discussed in this report are somewhat conceptual in nature, the identified difference in cost between open pit and underground mining is sufficiently large that, in Micon's judgement, the result can be regarded as conclusive. Accordingly, it is Micon's opinion that future planning of production from the drill-proven reserve at the Restigouche property should be restricted to mining by open pit methods.

It is emphasized, also, that the comparative cost analysis presented herein is confined to the extraction of the drill-proven reserve. The Restigouche deposit remains open down-plunge and additional ore may ultimately be demonstrated to exist in this area. It is Micon's opinion that mining of the drill-proven reserves as an open pit will not result in the sterilization of any ore which may exist in a down-plunge extension, beyond the limits of the current drill-proven reserve. Any such extension could still be mined by either open pit or underground methods.

OPEN PIT MINING

PIT RESERVES

Roscoe Postle has developed a preliminary layout for mining the drill-proven reserve at the Restigouche property by open pit methods and has estimated that the resulting pit contains 5.91 million tonnes of waste and 1.02 million tonnes of ore grading 7.38 per cent zinc and 5.60 per cent lead, at an overall waste ratio of 5.8 tonnes of waste per tonne of ore.

The pit layout was prepared with the aid of a computer program which was unable, in the time available, to incorporate the design of the ramp required to haul ore and waste to surface. Moreover, the north and south branches of Charlotte Brook traverse the southern portion of the surface area encompassed by the preliminary pit. The present plan of development calls for diverting the north branch of the brook into the south branch at a point upstream of the western edge of the pit. This would enable open pit mining to proceed through the present course of the north branch, but would preclude a close approach to the south branch.

For these reasons, Micon has adjusted the pit design manually, first, to restrict the southern limit of the pit to a point north of the south branch of Charlotte Brook and, secondly, to make provision, within the pit walls, for a spiral haulage ramp, 20 meters wide, at a gradient of 8 per cent. Micon has also made allowance for mining dilution of 5 per cent of the in situ ore tonnage; the grade of the diluting material has been assumed as zero.

The adjustments made by Micon to the quantities of ore and waste contained within the preliminary pit designed by Roscoe Postle are summarized in Table I. It can be seen that the pit design adopted by Micon is estimated to contain 6.01 million tonnes of waste and 0.99 million tonnes of ore grading 7.0 per cent zinc and 5.3 per cent lead, at an overall waste ratio of 6.1 tonnes of waste per tonne of ore. These quantities are contained within a pit which is 300 meters long by 200 meters wide at the crest, and has a maximum depth of approximately 100 meters. The overall slope of the pit walls is about 45 degrees.

The quantities shown in Table I have been used by Micon as the basis for estimating the capital and operating costs associated with mining the drill-proven reserve at the Restigouche property by open pit methods. It is emphasized that no attempt has been made to optimize the pit layout and, accordingly, some further variation in ore and waste quantities is to be expected as pit planning proceeds towards final design.

PRODUCTION SCHEDULE

As noted above, the preliminary pit designed to recover the drill-proven reserve contains 1 million tonnes of ore and 6 million tonnes of waste. Micon has estimated, grossly, that approximately 400,000 tonnes of waste will need to be removed, during the pre-

TABLE I

ADJUSTMENT TO PIT QUANTITIES

	Quantities (thousand tonnes)		Ore Grade (%)	
	Waste	Ore	Zinc	Lead
Preliminary pit - Roscoe Postle	5,915	1,020	7.4	5.6
Material lost in restricting South Boundary	(270)	(80)	7.4	5.6
Waste added by inclusion of Haulage Ramp	415	-	-	-
Mining dilution	(50)	50	-	-
Pit Quantities Adopted by Micon	6,010	990	7.0	5.3

production phase, in order to prepare the pit for sustained commercial operation. Accordingly, it is estimated that, during the operational phase, 5.6 million tonnes of waste and 1 million tonnes of ore will be removed from the pit, at an average waste ratio of 5.6 tonnes of waste per tonne of ore.

It is presently planned to mine the pit at an average rate of 4,250 tonnes of waste and 750 tonnes of ore per day. At this rate of production, the drill-proven reserve would be mined out in approximately four years.

EQUIPMENT REQUIREMENTS AND COSTS

It is planned to mine the open pit by conventional techniques of drilling, blasting, loading with mobile front-end loaders and hauling with off-highway trucks. It is planned, also, to utilize a fleet of rock trailers, suitable for highway travel, to transport run-of-mine ore to a concentrator located some 35 kilometers from the Restigouche property.

Roscoe Postle has developed a schedule of the equipment required to mine 4,250 tonnes of waste and 750 tonnes of ore per day and to deliver the ore to the off-site concentrator, and has also prepared an estimate of the capital cost of this equipment. Roscoe Postle's schedule of equipment requirements and capital costs, as modified slightly by Micon, is reproduced in Table II.

CAPITAL EXPENDITURE

Micon has reviewed the estimates prepared by Roscoe Postle of the

TABLE II

RESTIGOUCHE PROPERTY

OPEN PIT EQUIPMENT COST

	Quantity (in Units)	Unit Price	Total
PRODUCTION EQUIPMENT			
Track drill (4")	2	$371,600	$ 743,200
Jack leg	3	3,500	10,500
150 CFM compressor	2	15,000	30,000
FEL loader (5.2 yd³)	2	293,300	586,600
Off-highway truck (35t)	5	315,000	1,575,000
Highway rock trailer (25t)	4	80,000	320,000
Blasting machines and instruments	1	4,000	4,000
Blasting cable	1	8,000	8,000
SERVICE EQUIPMENT			
Grader (180 hp)	1	301,500	301,500
Dozer (285 hp)	1	397,400	397,400
Fuel truck	1	25,000	25,000
Water truck	1	25,000	25,000
Service truck	1	30,000	30,000
Snow plows	1	35,000	35,000
Pickup truck	4	20,000	80,000
Ambulance	1	25,000	25,000
Shop tools		50,000	50,000
Office equipment		20,000	20,000
Surveying equipment		10,000	10,000
Safety equipment		10,000	10,000
Dry house furnishing		20,000	20,000
Miscellaneous		10,000	10,000
			$4,316,200
Mobilization to site (5%)			215,800
Unloading and servicing to start (10%)			431,600
Total			$4,963,600

Source: Roscoe Postle Associates Inc., as modified by Micon.

pre-production capital expenditures involved in preparing the Restigouche property for mining by open pit methods. In Micon's judgement, total capital expenditures are most likely to be $11.2 million, comprising the following elements:

	Capital Cost ($ thousand)
Engineering	200
Pre-production stripping	1,600
Mine equipment	5,000
Buildings and surface facilities	1,600
Direct Capital Cost	8,400
Contingency (12%)	1,000
Working capital	1,800
TOTAL CAPITAL EXPENDITURE	11,200

Engineering

Roscoe Postle has estimated that detailed engineering studies, required prior to the commencement of pit operations, will cost approximately $200,000. Micon regards this estimate as reasonable.

Pre-Production Stripping

It will be necessary to remove a certain amount of waste prior to the commencement of commercial operation, in order to develop a number of ore faces sufficient to sustain the design rate of production of 750 tonnes of ore per day. Micon has estimated, grossly, that this will require the stripping of approximately 400,000 tonnes of waste during the pre-production phase.

It is anticipated that this work will be undertaken by a contractor, at a cost of about $4 per tonne of waste removed. Accordingly, Micon estimates the cost of pre-production stripping at $1.6 million.

Mine Equipment

Micon regards as reasonable the estimate of $5.0 million developed by Roscoe Postle for the cost of mine equipment. Details of this estimate are shown in Table II, included previously.

Buildings and Surface Facilities

Roscoe Postle, with the assistance of Leslie Engineering (1988) Limited, has estimated the cost of ancillary buildings and surface facilities, in addition to those already existing at the property, at $1.33 million, as shown in Table III.

Micon has increased this estimate by $270,000 as an allowance for the cost of works associated with protection of the environment, particularly the control and treatment of potential acid run-off from sulphide-bearing waste. Accordingly, Micon has assessed the capital cost of the buildings and surface facilities required for open pit mining of the Restigouche deposit at $1.6 million.

Contingency

At the present stage of pit design and project engineering, it is Micon's judgement that a contingency allowance of 12 per cent should be applied to all components of the capital cost estimate.

Working Capital

In Micon's opinion, provision should be made for working capital

TABLE III

RESTIGOUCHE PROPERTY

OPEN PIT SERVICES COST ESTIMATE

Services Cost	
Site preparation, roads	$ 500,000
Repair shop	402,000
Fuel storage and distribution system	46,000
Yard lighting	30,000
Water supply system	152,000
Fire protection	3,000
Diesel generator	46,000
Security/first aid trailer	18,000
Dry house	56,000
Lunch trailer	18,000
Septic system	13,000
Open pit perimeter fence	46,000
Total	$1,330,000

Source: Roscoe Postle Associates Inc., as modified by Micon.

in an amount equal to the total cash cost of operating the Restigouche property for a period of three months.

As described subsequently, the cash cost of open pit mining of ore and waste, and of delivering ore to the concentrator, is estimated at $27 per tonne of ore. Production is scheduled at the rate of 262,500 tonnes per year, or about 66,000 tonnes in a three-month period. Working capital requirements, therefore, are estimated at $1.8 million.

OPERATING COSTS

Micon has reviewed the estimates prepared by Roscoe Postle of the cash operating costs associated with mining the drill-proven reserves at the Restigouche property by open pit methods and delivering the ore to an off-site concentrator. In Micon's judgement, total cash operating costs are most likely to be $27 per tonne, comprising the following elements:

	Operating Cost ($/tonne)
Drilling	1.35
Blasting	2.75
Loading	2.00
Mine haulage	4.90
Direct Mining Cost	11.00
Site services	6.50
Environmental expense	0.75
Administration	3.30
Indirect On-Site Cost	10.55
Haulage to concentrator	5.40*
TOTAL OPERATING COST	26.95

* See appendix.

Drilling

Roscoe Postle has made provision for the manning of a single drill for two shifts per day, five days per week. In view of the projected need to move drilling equipment frequently from bench to bench, Micon considers it prudent to allow for one additional driller, on a day shift only, five days per week. As a result, Micon has adopted a drilling cost of $1.35 per tonne of ore, or some 12 cents per tonne in excess of Roscoe Postle's estimate.

Blasting

Roscoe Postle has estimated blasting costs at $2.92 per tonne of 7
ore. Micon favours a slightly lower cost of $2.75 per tonne.

Loading

Micon accepts as reasonable Roscoe Postle's estimate of loading costs at $2 per tonne of ore.

Mine Haulage

Micon accepts as reasonable Roscoe Postle's estimate of mine haulage costs at $4.90 per tonne of ore.

Haulage to Concentrator

Roscoe Postle has estimated the cost of haulage from the mine site to the concentrator at $4.60 per tonne of ore. Micon has made provision for one additional loader operator on each shift, with the result that Micon's estimate of the cost of off-site haulage is $5.40 per tonne.

Site Services

The cost of site services, including maintenance personnel, operators and running expenses for miscellaneous equipment, and sundry labour, has been estimated by Roscoe Postle at $6.50 per tonne of ore. Micon agrees with this estimate.

Environmental Expense

Micon has incorporated, within the operating cost estimates, a nominal allowance of $200,000 per year, or 75 cents per tonne of ore, for the cost of environmental measures such as the treatment of acid water run-off.

Administration

Micon accepts as reasonable Roscoe Postle's estimate of administration expense, at $3.30 per tonne of ore.

UNDERGROUND MINING

The nature of the Restigouche deposit, which is both shallow and easily accessible, renders it potentially mineable by underground methods and, at the request of Marshall, Micon has undertaken a preliminary assessment of the technical feasibility and probable cost of underground mining.

As in the case of open pit mining, the analysis has been confined to the extraction of the current drill-proven reserve. The data base used in the evaluation comprised geological plans and sections of the drill-proven reserve, provided by Westoll. These data were compiled from the results of surface drilling, conducted at approximately 15-meter centers.

There has been no exploration development carried out underground at the Restigouche property. It has been necessary, therefore, to make certain assumptions with respect to achievable stoping layouts and dimensions. These assumptions are identified in the following sections of this report.

RESERVES AND THE SELECTED STOPING METHOD

General Considerations

The geological reserve compiled by Westoll has been accepted as the foundation for estimating the likely mineable reserve using underground methods. The in situ, drill-proven reserve is estimated by Westoll at a level of about 1 million tonnes at an average grade of 7.76 per cent zinc and 6.06 per cent lead. This reserve has been outlined in a plan location between Northings 2850 and 3150 and Eastings 9950 and 10050.

The salient characteristics of the Restigouche deposit, as they relate to underground mine design, and in particular to the stoping method and the mineable reserves, are itemized below:

- The deposit plunges at about 25 degrees to the north and dips between 20 and 40 degrees to the west.
- The ore, comprising hard, massive sulphides, is intersected by a dyke and offshoots, and carries hanging wall and footwall contacts that roll or undulate significantly in the strike, dip and plunge dimensions.
- Vertical thickness of the massive sulphides varies from a few meters up to 40 meters. Similarly, in the horizontal plane, width of the deposit can vary from a few meters to as much as 60 meters.
- Maximum thickness and width of the deposit occur when mineralized zones coalesce to form a series of mineable blocks, more or less continuous over a 150-meter strike length.
- The aforementioned mineable ore blocks are located at depths between elevations of +400 and +340, depending on plunge and dip. Ore above the +400 elevation may not be mineable by underground methods, due to crown pillar considerations or due to potential cost for overburden removal.

The above characteristics permit consideration of a suite of possible stoping methods, including room-and-pillar, cut-and-fill and long-hole stoping, or a combination of these methods. The main stoping consideration, however, dictated by the variability in the three dimensions of the deposit, is maximum underground extraction of ore at lowest cost, together with minimum dilution of ore with waste material.

Room-and-pillar methods were rejected on the basis of high stope development and production cost, a potentially low mining recovery of ore, and the height of backs.

The remaining stoping methods, namely cut-and-fill and long-hole stoping, are, in the opinion of Micon, the only viable stoping alternatives for Restigouche at the present stage of mining feasibility studies. The technical attributes of both methods, as they might be applied at Restigouche, are compared below:

	Cut-and-Fill	Long-Hole
Sub-levels	Least	
Stope pillars	Yes	Yes
Pillar recovery	No	Possible at a cost
Reserve lost to pillars	±30%	±30%
Stope fill	Yes	Maybe
Dilution control	Best	Difficult
Stope preparation and development cost	Least	
Direct stoping cost		Least
Primary development capital	Least	

While the comparison of technical attributes indicates that the choice of method is not clear cut, reference to the longitudinal sections and cross sections shows that the balance favours cut-and-fill on control of dilution.

There is no doubt that, on a strict comparison of direct operating cost, long-hole stoping would be significantly cheaper than cut-and-fill stoping. On the other hand, however, the application of long-hole stoping would require significantly more development than would cut-and-fill stoping. Micon's preliminary analysis of underground mining of the drill-proven reserves at Restigouche indicates that, on the basis of total operating and development cost, there is little to choose between the two methods.

In light of this conclusion, Micon has based its analysis of underground mining on the use of cut-and-fill stoping, on the grounds that this method provides better grade control and, hence, a higher revenue per tonne of ore mined. Stated alternatively, Micon has concluded, on the basis of the available data, that cut-and-fill mining is likely to yield the higher net cash flow per tonne of ore mined.

Micon's preliminary analysis indicates, also, that application of either cut-and-fill or long-hole stoping would result in the sterilization of approximately 30 per cent of the in situ reserve in supporting pillars, leaving some 700,000 tonnes of the in situ, drill-proven reserve as mineable. Moreover, using cut-and-fill stoping, dilution is estimated at about 12 per cent, with the result that the total drill-proven reserve mineable by underground methods is estimated at 800,000 tonnes.

The Stoping Method

The design features of the non-captive mechanized cut-and-fill stoping method are:

Dimensions: Width of the individual stope backs, in ore, of between 10 and 12 meters, situated between permanent rib pillars of widths between 4 and 5 meters.

Orientation: To favour maximum horizontal width of ore, estimated to trend northwest to southeast in the main 'pod' of ore where the mineralized zones coalesce.

Stope Strike Length: Variable, but assumed to average 50 meters in the 'pod'.

Height of Stopes: Variable up to 40 meters.

Access: Individual stope declines of length about 75 meters, at about 15 per cent inclination, providing access for men and machinery, are to be driven at 15-meter centers off a footwall drive on the 385 level. The decline backs are slashed with progressive stope lifts (from -15 per cent to +15 per cent). Secondary access for escapeways and ventilation is by means of stope raises of length 30 meters. Stope fill raises are to be established at 15-meter centers, connecting each stope to the 400 level. A single fill raise to surface provides the feed for stope fill raises on the 400 level.

Roofbolting: Split sets, plates and straps installed at 1-meter centers.

Manpower: Stoping on a 5-day week, double-shift schedule requires two lead miners and four miners per day in each stope.

Productivity: Assuming breast drilling, the direct stoping productivity is a maximum of 44 tonnes per manshift per stope (264 tonnes per day). Projected productivity is held at 200 tonnes per day (33 tonnes per manshift) on account of potential delays due to breakdown of equipment, stope filling, and roofbolting. Moreover, the nature of the ore body, as previously described, will affect productivity on those occasions which require increased mining selectivity.

The scale of the mineable reserves and the physical characteristics of the deposit are important considerations in assessing the sustainable production capacity at Restigouche. While mining may initially produce at the rate of 1,000 tonnes of ore per day in the 'pod', sustainable capacity is estimated by Micon at a level of 800 tonnes per day. This level of production requires 4 stoping units, which can readily be established in the main 'pod' of ore, with additional units in the process of preparation or ready for operation. In this way, it is foreseen that a degree of operational flexibility will be maintained, providing some security for the projected production rate.

PRIMARY MINE DEVELOPMENT LAYOUT AND SCHEDULE

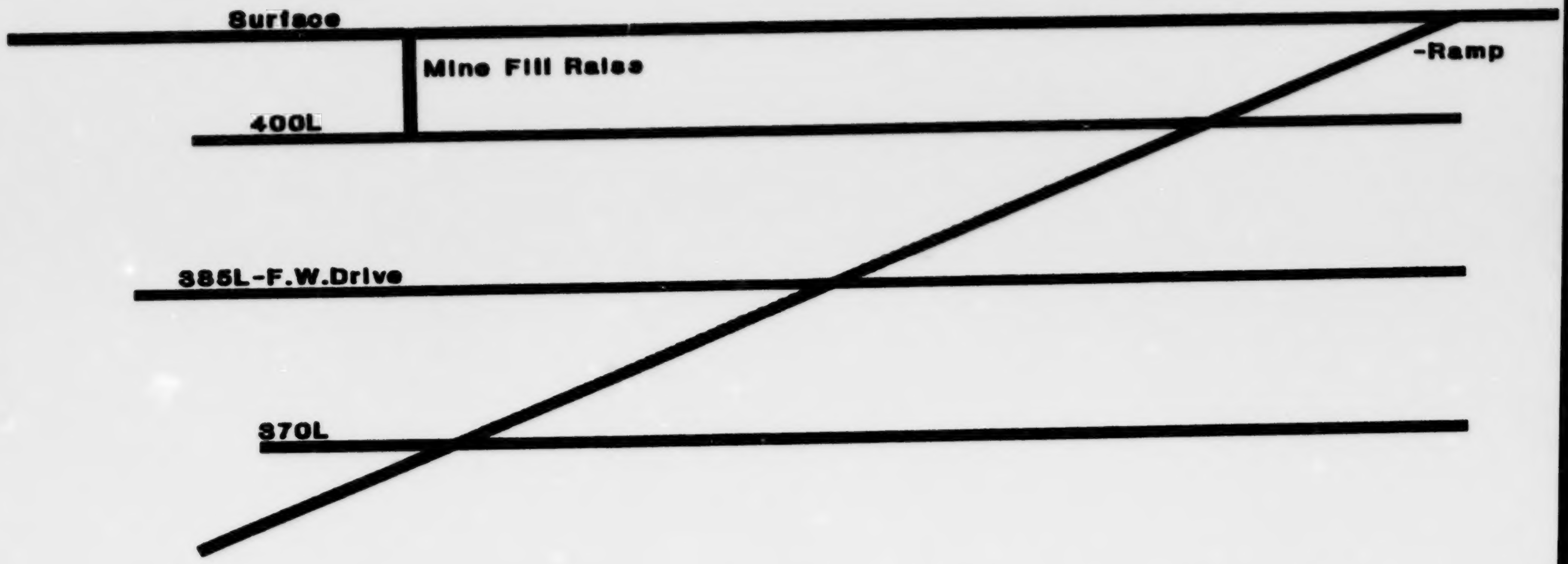
Layout

The primary mine development layout, shown in Figures 1 and 2, comprises:

- A decline or ramp from surface, at a -12 per cent inclination, providing access to the 400, 385 and 370 levels.
- A footwall drive on the 385 level.
- Strike drifts in ore on the 400 and 370 levels.
- Stope access declines, at 15-meter centers, driven at -15 per cent inclination from the 385 level footwall drift.
- Thirty-meter vertical stope raises for ventilation and escapeways.
- Thirty-meter vertical fill raises in each stope.
- A mine fill raise to surface from the 400 level.

Dimensions of the ramp and drifts are projected at 5 meters wide by 4 meters high. These openings are sized to accommodate 30-tonne

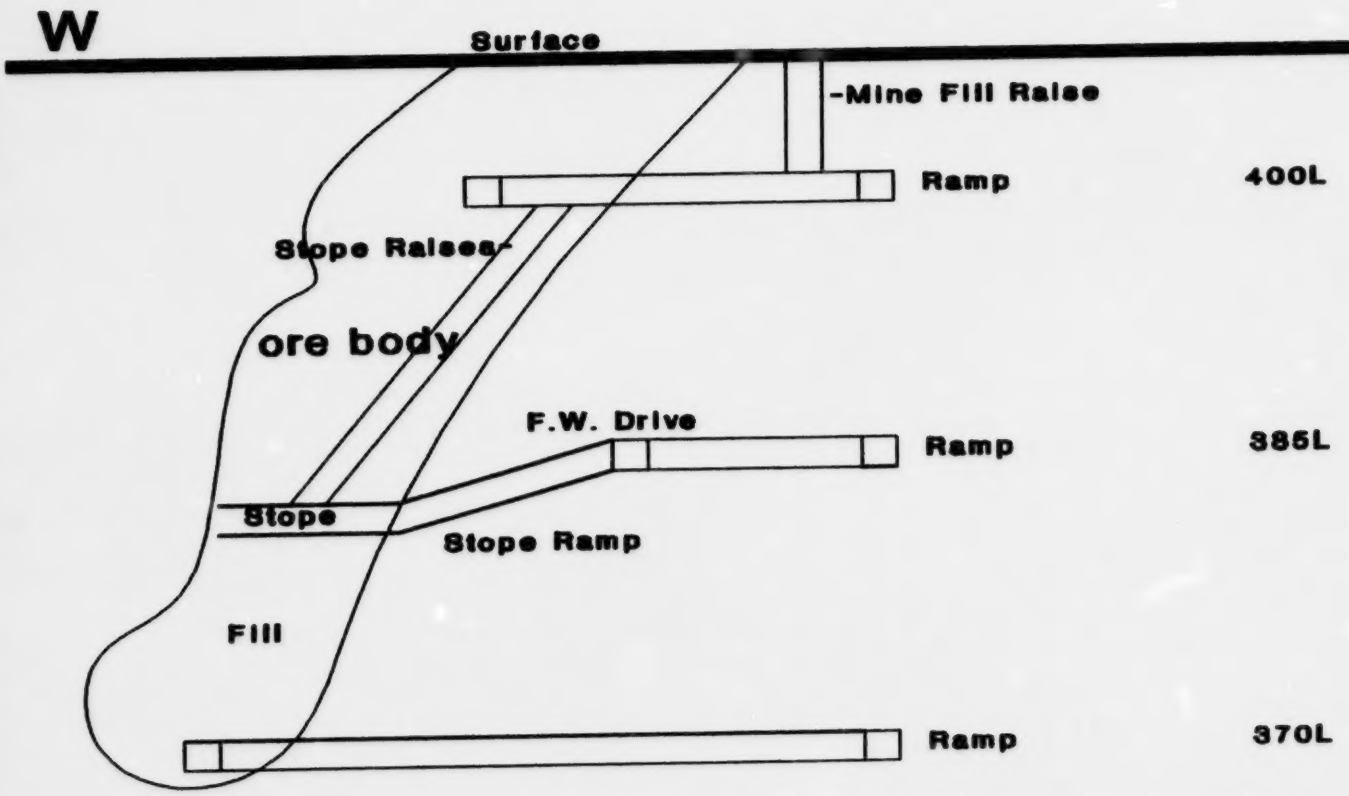
RESTIGOUCHE DEPOSIT


Surface
Mine Fill Raise
-Ramp
400L
385L-F.W.Drive
370L

LONGITUDINAL SECTION (SCHEMATIC)

FIGURE 1

RESTIGOUCHE DEPOSIT


W
Surface
-Mine Fill Raise
Ramp
400L
Stope Raises-
ore body
F.W. Drive
Ramp
385L
Stope
Stope Ramp
Fill
Ramp
370L

CROSS SECTION (SCHEMATIC)

FIGURE 2

trucks and ST 3.5 scooptrams. Stope and fill raise dimensions are projected at 2 meters by 2 meters.

Total primary mine development requirements and associated capital expenditures are shown in Table IV.

Schedule

The total pre-production mine development is estimated at about 2,600 meters, including about 1,600 meters in waste rock and about 1,000 meters in ore.

Assuming a rate of about 325 meters of development per month, carried out by a contractor on a 7-day per week, 3-shift per day schedule, a period of about 8 months would be required to accomplish this work.

CAPITAL COSTS

Estimated capital costs, based on the mining plan and primary mine development layout discussed above, are summarized below:

	Capital Cost ($ thousand)
Mine development (direct)	3,000
Mine development (indirect)	1,200
Mine equipment	3,200
Buildings and services	1,300
Engineering	200
Direct Capital Cost	8,900
Contingency (12%)	1,100
Working capital	2,100
TOTAL CAPITAL EXPENDITURE	12,100

TABLE IV

RESTIGOUCHE PROPERTY

ESTIMATED DIRECT MINE DEVELOPMENT CAPITAL

UNDERGROUND MINE

Heading		Meters	Tonnes	Unit Cost ($/meter)	Total Cost ($ thousand)
Ramp:		300	16,200	1,000	300
Strike Drifts:					
- In ore	400 level	200	17,500	1,100	220
	370 level	200	17,500	1,100	220
- In footwall	385 level	200	10,800	1,000	200
Crosscuts in Ore:					
	400 level	300	26,200	1,100	330
	370 level	300	26,200	1,100	330
Stope Ramps:					
	385 level	450	24,300	1,000	450
Fill Raises:					
	370-400 level	180	1,900	600	108
	To surface	40	400	600	24
Stope Ventilation Raises:					
	370-400 level	180	1,900	800	144
	To surface	40	400	800	32
Miscellaneous Drifts:		200	10,800	1,000	200
Definition Drilling:		6,750	-	15	101
Sub-Total					2,659
Contractor fee and overhead				400	
Total Mine Development					3,059

Mine Development

Supporting detail for the direct mine development capital cost is given in Table IV. It has been assumed that:

- A mining contractor will be retained to carry out the mine development work, including definition drilling underground.
- Miscellaneous drift work, about 200 meters in total length, will comprise some connecting crosscuts, pump chambers, lunch room, powder magazines, et cetera.
- Provisions for accommodation for the contractor workforce will be covered in the contingency allowance on total estimated capital.
- Underground mobile equipment will be provided by Marshall.

Mine development indirect cost is in addition to the direct costs shown in Table IV. It is an allowance for the contractor's costs for mobilization and set up, hourly paid maintenance and mucking crews, general supervision, engineering and administration, supplies, et cetera.

Mine Equipment

The projected mine equipment requirements and capital costs are estimated as shown in the following tabulation. The provision for miscellaneous equipment is an allowance for compressors, pumps, water treatment facilities, ambulance, shop tools, office equipment, furnishings, safety equipment, et cetera.

Equipment	Quantity	Unit Cost ($ thousand)	Total Cost ($ thousand)
ST 3.5 scooptrams	3	190	570
30t trucks	3	230	690
Single-boom drill jumbos	3	180	540
Scissor lifts	2	70	140
D4 dozers	2	40	80
Utility vehicles	2	16	32
3.5m front-end loader	1	300	300
50-man buses	2	50	100
Highway trucks	4	80	320
Miscellaneous			400
			3,172

Buildings and Services

The capital cost of buildings and services, at a level of $1.3 million, is based on Table III, with adjustments for exclusion of the open pit perimeter fence.

Engineering

The cost of $200,000 is based on the estimate by Roscoe Postle for detailed engineering and design for an open pit. It is the opinion of Micon that engineering costs for an underground mine would likely be at a similar level.

Contingency

In addition to normal contingencies, this allowance is to cover contractor workforce accommodation and is also a provision for small dump pads on surface for broken rock, including treatment facilities for acid surface water run-off.

Working Capital

The requirement for working capital is an allowance for the cost of commercial production in the first three months of operations (65 operating days). Based on 800 tonnes mined per day and a unit operating cost of $41 per tonne, the working capital is estimated at a level of about $2.1 million.

OPERATING COSTS

Micon has compiled its estimate of the unit operating cost for cut-and-fill mining in the following manner:

1. Conceptual development and stoping layouts were derived from reserve plans and sections provided by Marshall and its consultants.
2. An equipment list was drawn up using productivity data in Micon's files.
3. A manpower list was developed and a labour cost was derived using current industry wage scales, with typical allowances for incentive bonus and payroll overhead.
4. A schedule of operating supplies was developed and costed. Drilling, blasting and roofbolting supplies were each estimated separately. The cost of operating supplies for mobile equipment was extracted from data in Micon's files.
5. A schedule of staff requirements was drawn up and the cost of supervisory, technical and administrative services was derived using typical salary levels and salary-to-supplies cost ratios. Provision for environmental costs was included in this category.
6. It was assumed that waste rock, suitable for stope filling, would be quarried nearby on surface, at a contracted cost of $3 per tonne broken. Assuming a swell factor of 60 per cent, this cost would be equivalent to $1.80 per tonne of ore mined.

Details of the cost estimate derived using these procedures are provided in Appendix I. Total operating costs are estimated at $41 per tonne, comprising the following elements:

	Operating Cost ($/tonne)
Production	26.08
Development	1.69
Fill contract	1.80
Direct Mining Cost	29.57
Maintenance	1.01
Technical and Administration services	5.59
Environmental	.50
Indirect On-Site Cost	7.10
Haulage to concentrator	4.33*
TOTAL OPERATING COST	41.00

* See appendix.

Micon has compared its estimate of $28.78 per tonne for production, development and maintenance with actual cost data for certain other generally similar operations. A satisfactory level of agreement was found.

POTENTIAL FOR FURTHER DEVELOPMENT

In Micon's judgement, the comparative cost analyses presented in this report demonstrate conclusively that the current drill-proven reserves at the Restigouche property should be mined by open pit, rather than underground, methods.

The Restigouche deposit remains open down-plunge and there is no question that mineralization continues in this direction. The available drill data, however, are presently inadequate to determine the tonnage, grade and, in particular, the continuity and spatial distribution of the additional mineralization to a commercially acceptable level of assurance. Because of the lack of more definitive data, no mining plans have yet been developed by Marshall for the extraction of any reserves which may ultimately be demonstrated to exist in this area.

The overall process of reserve definition, mine planning and economic analysis, for any mineral deposit, invariably proceeds in stages. It is generally accepted professional and business practice to commence commercial development when ore has been demonstrated to exist in sufficient quantity to render its extraction commercially viable, provided that such development does not jeopardize the recovery of any additional ore which may be delineated subsequently.

At the present time, it is not possible to determine the more economic method of mining any down-plunge extension of the Restigouche deposit, assuming that this extension is ultimately demonstrated to constitute ore.

Should it be found, however, that any such reserves are more economically mined by underground techniques, it is Micon's opinion that the existence of an adjacent pit is likely to facilitate, rather than impede, their extraction. In particular, underground development of these reserves could be undertaken from the pit bottom, obviating the need for a primary access ramp from surface.

Moreover, even if any down-plunge reserves are eventually mined by underground methods, it will not be necessary, in Micon's judgement, to incur significant additional capital expenditures. It is not uncommon for underground mining operations based on limited reserves to be undertaken by contract, specifically to avoid incurring capital expenditure for equipment which has a useful operating life greater than the life of the reserves. Although the owner may be required to provide certain facilities, such as ventilation, the contractor provides all of the capital equipment.

In light of these observations, it is Micon's opinion that the mining of the current drill-proven reserves at Restigouche by open pit methods will not render sterile any additional reserves which may ultimately be demonstrated to exist in a down-plunge extension of the deposit.

CONCLUSION

The principal characteristic of the Restigouche deposit is that it contains a relatively small tonnage of relatively high grade material. Under these circumstances, it is important to extract the largest possible proportion of the in situ reserve. All other things being equal, therefore, open pit techniques are to be preferred since, inevitably, underground mining results in the loss of ore to supporting pillars.

In Micon's opinion, there is also a demonstrable cost advantage in mining the current drill-proven reserve as an open pit. Micon has concluded, therefore, that open pit mining of this reserve is preferred on both technical and economic grounds.

Since the Restigouche deposit remains open down-plunge, it is important to ensure that mining of the drill-proven reserve as an open pit will not preclude the subsequent economic extraction of any extension of the deposit, beyond the limits of the current drill-proven reserve. In this regard, it is Micon's opinion that:

1. The more economic method of mining a down-plunge extension cannot be determined at this time. It remains possible that such an extension could be mined as an expansion of the initial pit.
2. The existence of an adjacent pit would facilitate, rather than impede, underground mining of a down-plunge extension, since development could be undertaken from the pit floor.
3. Should the down-plunge extension be of limited extent, but still require underground mining, it could be mined under contract, avoiding the need to invest any significant amount of additional capital.

For these reasons, it is Micon's opinion that mining of the drill-proven reserves by open pit methods will not result in the sterilization of any ore which may exist in a down-plunge extension to the north of the presently defined reserve. Such ore, should it be demonstrated to exist, could still be mined by either open pit or underground techniques.

APPENDIX I

OPERATING COST ESTIMATES

PRODUCTION COSTS

Labour	Rate per Day	Cost	
Lead miners (8)	257	2,056	
Miners (16)	249	3,984	
Underground truckers (4)	185	740	
Backfillers (2)	185	370	
Equipment operators (3)	150	450	
Service man (1)	150	150	
Warehouseman (1)	150	150	
Janitor (1)	150	150	
		Total	8,050

Supplies

Blasting: Explosives 480 kg @ $5.01/kg	2,405	
Detonators 192 @ $2.51	482	
Miscellaneous @ 5%	144	
		3,031
Drilling: 213 meters @ $4.92/meter		1,048
Roofbolting: 168 sq.m. @ $10.50		1,764
Operating Supplies (1):		
Scoops (3 scoops @ 12 hrs. @ $55/hr)	1,980	
Trucks (3 trucks @ 12 hrs. @ $55/hr)	1,980	
Jumbos (3 jumbos @ 7 hrs. @ $30/hr)	630	
Scissor lifts (2 lifts @ 7 hrs. @ $10/hr.)	140	
Dozers (2 dozers @ 7 hrs. @ $55/hr.)	770	
FEL (1 FEL @ 18 hrs. @ $55/hr.)	990	
Other (2): (4 @ 12 hrs. @ $10/hr.)	480	
	Total	6,970
Grand Total Production Costs		20,863
Cost/tonne		$26.08

(1) Fuel, lubricants, tires, spares, et cetera.

(2) Buses, utility trucks.

DEVELOPMENT COST

	Total Cost
Explosives (3.3 meters @ $160/meter)	528
Drilling (3.3 meters @ $250/meter)	825
Total	1,353
Cost/meter	$410
Cost/tonne	$1.69

* Labour included in production cost.

MAINTENANCE COST

LABOUR:

	Rate per Day	Total Cost
Master mechanic (1)	205	205
Mechanics (2)	200	400
Electrician (1)	200	200
Total		805
Cost/Tonne		$1.01

* Supplies are included in production costs.

SUPERVISION, TECHNICAL, ADMINISTRATION

STAFF:

	Rate per Day	Total Cost
Mine superintendent (1)	423	423
Shifters (2)	272	544
Mine engineer (1)	363	363
Geologist (1)	302	302
Surveyor (1)	242	242
Sampler (1)	242	242
Safety supervisor (1)	272	272
Accountant (1)	272	272
Clerk timekeeper (1)	150	150
Secretary (1)	150	150
Security (3)	150	450
Total		3,410
Total Cost Assuming Labour: Supplies Ratio of 70:30		4,871
Cost/Tonne		$6.09

* Supplies cost includes an allowance of $0.50/tonne for environmental costs.

ORE HAULAGE TO MILL

	Rate per Day	Total Cost
Labour: 9 men	185	1,665
Supplies:		
25t Highway trucks (3 @ 20 hrs. @ $30/hr.)		1,800
Total		3,465
Cost/Tonne		$4.33

* Cost for hauling ore to the mill, shown as $4.33 per tonne, is different to the open pit cost of $5.40 per tonne. The difference is attributable to a re-distribution of supervision costs. The adjusted Roscoe Postle estimates used in the pit study are based on apportioning the pit and shift foremen between production and ore haulage. The underground cost study allocates all supervision costs to supervision and technical. The cost of front-end loader operators is allocated to production costs.

HOURLY PAID WAGE RATES

(Total per Day)

	Wage	Overtime	Bonus	Burden	Total
Lead miner	118	14	96	29	257
Miners	112	13	96	28	249
Underground truckers	104	12	48	21	185
Backfillers	104	12	48	21	185
Master mechanic	120	14	48	23	205
Mechanic	116	13	48	23	200
Electrician	116	13	48	23	200
Serviceman	104	12	16	18	150
Warehouseman	104	12	16	18	150
Equipment operators	104	12	16	18	150
Janitor	104	12	16	18	150
Surface truckers	104	12	48	21	185

SALARIED STAFF WAGE RATES

	$/Day
Mine superintendent	423
Mine engineer	363
Geologist	302
Shifters	272
Surveyor	242
Sampler	242
Safety supervisor	272
Accountant	272
Clerk/timekeeper	150
Secretary	150
Security	150

* Same as Roscoe Postle, including a 33% payroll burden.

RESTIGOUCHE DEPOSIT

UNDERGROUND MINING - ESTIMATE OF MANPOWER

	Day	Afternoon	Night	Total
Supervision and Technical				
Mine superintendent	1			1
Shifters	1	1		2
Mine engineer	1			1
Geologist	1			1
Surveyor	1			1
Sampler	1			1
Safety supervisor	1			1
Accountant	1			1
Clerk/timekeeper	1			1
Secretary	1			1
Security	1	1	1	3
Sub-Total	11	2	1	14
Mine				
Lead miners	4	4		8
Miners	8	8		16
Haulage	2	2		4
Backfillers	—	2		2
Sub-Total	14	16		30
Shops and Services				
Master mechanic	1			1
Mechanics	1	1		2
Electrician	1			1
Serviceman	1	1		2
Warehouseman	1			1
Equipment operator	1	1	1	3
Truckers	3	3	3	9
Dry/janitor	1	—	—	1
Sub-Total	10	6	4	20
Grand Total	35	24	5	64

APPENDIX B

PUBLIC MEETING - JULY 6, 1989

A public information meeting concerning the Restigouche Property impact assessment was held on 6 July 1989 in Campbellton, New Brunswick. The purpose of the meeting was to identify public interest groups in the area, provide them with information on the proposed development, and hear concerns they may have about the project. Notices of the meeting were announced in several local newspapers for several days prior to the meeting. A number of public interest groups were contacted by telephone prior to the meeting to inform them of the meeting. Such groups included:

Atlantic Salmon Federation
New Brunswick Council of the Atlantic Salmon Federation
North West Salmon Association
Restigouche Salmon Club
Nepisiquit Salmon Association
Nepisiguit Trout Protection Association
New Brunswick Outfitters Association
New Brunswick Wildlife Federation
New Brunswick Trappers Association
Restigouche Riparian Association
Conservation Council of New Brunswick
New Brunswick Federation of Naturalists
Eel River Native Band
Restigouche Native Band

Approximately 15-20 persons representing some of the above groups, as well as other interests, attended the meeting. Although an attendance sheet was provided, not all of the people in attendance made note of their name or affiliation. A list of those persons who did make note of their presence is given in Table B1.

Following a summary of the EIA process and the proposed mining development, approximately 62 questions were raised by those in attendance. The majority of the questions dealt with various environmental aspects of the proposed mining development. Other topics of interest included employment (i.e. size of work force and where it would be sourced) as well as background information on Marshall Minerals Corp. Questions raised at the meeting are listed in Table B2. Following each question, the response given and/or the section of the report which has addressed these concerns is referenced.

TABLE B1

Partial List of Attendees at
Public Meeting, Campbellton, July 6, 1989

James T. Ryan	NWSA, President
E. St. Pierre	NWSA, Vice-President
Jean C. Thibodeau	NWSA, Director
Bill Clarke	Campbellton Tribune
Michael Sprague	Environment New Brunswick
Vaclav Kresta	Environment New Brunswick
Yvette Bourgoin	Chamber of Commerce, Campbellton
Michel Gaudreau	Environment Vert-Plus, Quebec
Donald Dickie	N.B. Trappers Assoc., Vice-President
Don McKay	Telegraph Journal
William Murray	Restigouche Riparian Assoc.
Bob Butler	DNRE
Louis Arsenault	NTPA

TABLE B2

The following is a list of questions as were recorded during the meeting. The response is given below each question and/or reference is made to the section of the report addressing the concern.

---

1. What is Marshall's background in mining?

   - See Section 2.1.

2. Who is the major shareholder?

   - See Section 2.1.

3. Will the re-routing of haul roads and their possible effects on nearby streams be addressed in the EIA?

   - See Sections 3.3.2.

4. Will access roads be open to hunters and/or fishermen or will there be restricted access?

   - See Section 3.3.2.

5. What will be the final depth and size of open-pit? Will the pit pose a hazard to people unfamiliar with the area?

   - See Sections 3.1 and 3.4.

6. What will be the final quality of water in the open-pit? Will it be just a stagnant pool, or will there be some flow through?

   - See Section 7.1.

7. Why can't the site be reclaimed to its former appearance?

   - There is no need to do this because of the inert waste, and it would be too expensive (see Section 2.4.4).

8. What is the expected ore production from this pit?

   - See Sections 2.2.2 and 3.1.

9. Will any underground mining operation require another study?

   - See Section 2.4.1.

10. How many local jobs will be created?

    - See Sections 3.1, 3.5.4 and 6.6.1.

11. Will local jobs go to Campbellton or Bathurst residents?

    - Job vacancies will be advertised in all communities within the local area.

12. Where will the local office be - Bathurst or Campbellton?

    - Although a final decision has not been made, the local office will likely be in Bathurst.

13. Describe Charlotte Brook drainage (receiving waters).

    - See Section 4.2.1.

14. Effects of pyrite at Brunswick are well known, how will acid drainage be controlled in this case?

    - See Section 3.2.

15. Will the pond demonstration project at Caribou have results before the mining operation begins?

    - No, the pond demonstration project will not be completed before mine operation begins.

16. Why have other companies not developed this orebody in the past?

    - A brief history outlining the size of companies, the price of the commodities and the proximity of an existing mill was given.

17. What is the trucking distance from Restigouche to Caribou?

    - See Section 2.3.2.

18. What are the chances of rock faults and the resulting escape of contaminated water from the pit?

    - See Section 2.2.2.

19. What is the size of the settling ponds and their retention time?

    - See Section 3.2.3.

20. Will ore be stockpiled? How will it be stored?

    - See Sections 3.1 and 3.2.2.

21. What will be the size of the ore particles? Will there be a crusher on site?

    - See Section 3.1.

22. Is there any indication of naturally occurring arsenic?

    - See Section 2.2.2.

23. After the mining operation has been completed, what happens if the pit full of water does become contaminated?

    - See Section 7.1.

24. Is there any possibility of filling in the open pit?

    - See Section 2.4.4.

25. Are there any other ore deposits in the area?

    - Yes, there are other ore deposits in the area.

26. What is the straight line distance from Restigouche to NovaGold? Are there any similarities between the properties with respect to geology, ore handling, waste treatment?

    - It is less than 10 km to the NovaGold Murray Brook holding. Details of the NovaGold mine development are unknown at this time.

27. How far is the pit from the lake?

    - The proposed pit is 4 km from Upsalquitch Lake.

28. How long will the EIA study take?

    - The EIA is scheduled to be finished by spring, 1990 (see Section 3.1.1).

29. Will this be a year round mining operation?

    - Yes, the mine will run year round.

30. Wouldn't an earth cover over acid generating waste rock be more effective than a water cover?

    - See Sections 2.4.4 and 7.1.

31. Concern over size of settling - treatment ponds and retention time.

    - See Section 3.2.3.

32. Are there any similarities to this project and Brunswick #6 with respect to settling ponds and treatment process, etc?

    - Yes, in general, there are similarities between the two set-ups. However, they are not identical.

33. Would like to bring to everyone's attention that there are now 1-2 or possibly 3 mines proposed for the S.E. Upsalquitch River watershed, and the cumulative effect of their waste could be too much for the river.

    - See Section 6.7.1.

34. Some homegrown speculation on cumulative effects of mining on the fisheries of the Nepisiquit River. Seems like a big risk for short term benefits - take Little River for example.

    - New legislation will prevent similar incidents, such as occurred at Little River.

35. In spite of large recent profits, Bathurst Mines is doing little to fight pollution - how about a written guarantee to all user groups that any occurrence of pollution will result in the shutting down of mining operations until the problem is solved? Requesting a statement of good will from the company.

    - We are not authorized to give the company's approval to that request; we will, however, bring it to their attention.

36. Will the company place a bond to ensure against environmental damage?

    - Yes, there are in fact two bonds likely to be assessed against the property.

37. Sedimentation from roads is bad on fish. How will this problem be addressed in light of the hauling operation?

    - The haulage road will cross no streams (see Section 3.3.2).

38. Will the trucks be covered?

- No, it is not common practice to cover ore hauling trucks.

39. Is the dust from drilling acid generating? How will this be addressed?

- See Section 5.1.

40. Will the treatment system be in place before acid generating rock is encountered?

- See Section 3.2.3.

41. How thick is the acid generating waste rock layer?

- See Section 3.1.

42. How will the inert waste rock pile react to acid rain?

- See Section 3.2.1.

43. Describe liners for ponds and dumps.

- See Section 3.2.3.

44. Will there be a monitoring program for fish and invertebrates in streams?

- See Sections 4.2.3 and 8.3.

45. A letter of goodwill from the company is important. Caribou issued such a letter, why not this company?

- We will advise the company of this request.

46. How long is the company liable for the property after mining?

- See Section 7.1.

47. Is there any chance of seepage through the bedrock from the pit?

- See Section 2.2.2.

48. How long have studies been done on this site?

- A sampling program has been underway on the site since 1988.

49. How has the relationship been between the company and DMAE to date?

    - Marshall and DMAE are currently working together towards the development of this project.

50. What is the proposed frequency of fish and invertebrate monitoring?

    - See Section 8.3.

51. Will electrofishing data be available to user groups?

    - This information is given in Table 4.9 (Section 4.2.3.1).

52. In the event of a trucking accident, what happens to the ore?

    - See Section 6.4.2.

53. Is it possible that the open pit might someday provide fish habitat?

    - See Section 7.1.2.

54. Will the mine be developed by Marshall or some other separate group? Who will be liable in the event of environmental damage?

    - See Section 3.5.1.

55. What happens if Caribou closes in 2 years?

    - See Section 2.4.2 and 3.0.

56. In the event of a decision to start an underground mining operation, how will acid generating waste rock be handled?

    - See Section 2.4.1.1.

57. The Company should know that NTPA has no objection to a mining operation as long as it is handled responsibly.

    - Marshall has commissioned this EIA to determine both the most environmentally and economically sound mineral development prospects (see Section 2.4).

58. What will happen to the trees on the site?

    - See Sections 5.1.1 and 7.2.

59. Are there any deer or moose yards in the area, or any rare or unique plant or animal species?

- See Section 4.1.1.

60. Is information on the company available - share performance, company record, etc.?

- See Section 2.1.

61. What is the mining history of the company? Is this the first mine?

- See Section 2.1.

62. How many employees are in the company? Where is the head office? What is the status of the company - approximate cash flow?

- Corporate information will be forwarded to any interested parties present.

APPENDIX C

ACID GENERATION TESTS

Report No.: PCAS/89/124

Date: July 20, 1989

Job No.: 04000384/0490

Page 1 of 3

TO: Westall & Associates
Suite 207,
8 King St. E.
Toronto, ON
M5C 1B5
Attention: Neil Westall & Jim Burns

Analysis of Waste Rock for Acid Producing Potential

The analytical technique followed was that of BC Research previously obtained from them. The section "assay" on page six provides the analytical procedure. Line two states that "The use of the Leco furnace is recommended, although a chemical oxidation technique followed by barium sulphate precipitation is satisfactory". RPC followed the recommended procedure of analyzing sulphur by Leco furnace. This answers your query in your letter of June 19, 1989, and the results are provided below.

Sample No.	% S	A Theoretical Acid Production lb/ton	B Acid Consumed lb/ton	A - B	Theoretical Acid Producer
19401	0.04	2.45	16.95	-14.50	No
19402	0.05	3.06	30.87	-27.81	No
19403	0.33	20.19	12.64	+7.55	Yes
19404	0.46	28.14	37.34	-9.20	No
19405	0.15	9.18	23.57	-14.39	No
19406	0.07	4.28	12.05	-7.77	No
19407	0.21	12.85	35.57	-22.72	No
19408	0.30	18.35	35.57	-17.22	No
19409	0.04	2.45	32.05	-29.60	No
19410	0.15	9.18	26.26	-17.08	No
19411	0.08	4.89	27.63	-22.74	No
19412	0.06	3.67	46.06	-42.39	No
19413	0.26	15.91	50.18	-34.27	No
19414	0.25	15.30	62.92	-47.62	No
19415	0.19	11.62	104.47	-92.85	No
19416	0.21	12.85	45.77	-32.92	No
19417	0.10	6.12	85.46	-79.34	No
19418	0.10	6.12	51.84	-45.72	No
19419	0.15	9.18	28.91	-19.73	No

Report No.: PCAS/89/124 **Date:** July 20, 1989

Job No.: 04000384/0490 Page 2 of 3

TO: Westall & Associates

Sample No.	% S	A Theoretical Acid Production lb/ton	B Acid Consumed lb/ton	A - B	Theoretical Acid Producer
19420	0.04	2.45	22.10	-19.65	No
19421	0.01	0.61	23.62	-23.01	No
19422	0.01	0.61	53.31	-52.70	No
19423	0.22	13.46	55.37	-41.91	No
19424	0.20	12.24	121.91	-109.67	No
19425	0.10	6.12	217.71	-211.59	No
19426	1.03	63.02	316.93	-253.91	No
19427	2.94	179.87	67.52	+112.35	Yes
19428	3.45	211.07	59.88	+151.19	Yes
19429	0.10	6.12	23.42	-17.30	No
19430	0.14	8.57	15.73	-7.16	No
19431	0.55	33.65	39.20	-5.55	No
19432	1.26	77.09	182.48	-105.39	No
19433	0.05	3.06	20.48	-17.42	No
19434	0.02	1.22	15.09	-13.87	No
19435	0.10	6.12	31.85	-25.73	No
19436	0.09	5.51	40.47	-34.96	No
19437	0.16	9.79	39.91	-30.12	No
19438	0.04	2.45	34.30	-31.85	No
19439	0.48	29.37	111.72	-82.35	No
19440	1.77	108.29	83.55	+24.74	Yes
19441	0.47	28.75	57.62	-28.87	No
19442	0.53	32.43	51.16	-18.73	No
1401	9.06	554.29	41.65	+512.64	Yes
1402	7.81	477.82	51.84	+425.98	Yes
1403	2.09	127.87	46.84	+81.03	Yes
1404	1.86	113.79	17.74	+96.05	Yes
1405	2.26	138.27	36.90	+101.37	Yes
1406	2.43	148.67	21.95	+126.72	Yes
1407	4.13	252.67	30.09	+222.58	Yes
1408	4.36	266.74	29.20	+237.54	Yes
1409	8.45	516.97	20.78	+496.19	Yes
1410	3.62	221.47	17.10	+204.37	Yes
1411	1.87	114.41	25.77	+88.64	Yes
1412	3.50	214.13	9.02	+205.11	Yes
1413	2.19	133.98	10.29	+123.69	Yes

Report No.: PCAS/89/124

Date: July 20, 1989

Job No.: 04000384/0490

Page 3 of 3

TO: Westall & Associates

Sample No.	% S	A Theoretical Acid Production lb/ton	B Acid Consumed lb/ton	A - B	Theoretical Acid Producer
1414	1.21	74.03	17.84	+56.19	Yes
1415	3.44	210.46	21.07	+189.39	Yes
1416	4.01	245.33	18.52	+226.81	Yes
1417	1.96	119.91	12.05	+107.86	Yes
1418	3.67	224.53	5.68	+218.85	Yes
1419	4.92	301.01	8.43	+292.58	Yes
1420	4.17	255.12	11.66	+243.46	Yes
1421	2.54	155.40	317.52	-162.12	No
1422	2.36	144.38	52.53	+91.85	Yes
1423	2.75	168.25	29.01	+139.24	Yes
1424	3.90	238.60	19.80	+218.80	Yes
1425	3.76	230.04	58.56	+171.48	Yes
1426	3.76	230.04	81.93	+148.11	Yes
1427	4.06	248.39	96.53	+151.86	Yes
1428	3.99	244.11	14.01	+230.10	Yes
1429	3.25	198.84	10.68	+188.16	Yes
1430	2.13	130.31	26.81	+103.50	Yes
1431	1.85	113.18	170.13	-56.95	No
1432	2.34	143.16	95.26	+47.90	Yes

F E Campbell

F. E. Campbell
Analytical Chemist

I. J. I. Delaney

Dr. I. J. I. Delaney
Manager
Analytical Services

/smw

REPORT NUMBER: PCAS/89/295 DATE: November 7, 1989

JOB NUMBER: 04000384/0722

PCAS CODES: 722-1, - 722-22 Page 1 of 2

TO:
Neill Westall & Associates
Suite 207
8 King Street E.
Toronto, Ontario
M5C 1B5
Attn: Neill Westall & Jim Burns

Analysis of Waste Rock for Acid Producing Potential

Sample No.	% S	A Theoretical Acid Production lb/ton	B Acid Consumed lb/ton	A-B #4	Theor. Acid Producer
19948	0.002	0.122	10.78	-10.66	NO
19949	3.10	189.7	5.59	18.41	YES
19950	3.75	229.4	13.72	215.7	YES
19951	4.22	258.2	65.37	192.8	YES
19952	3.45	211.1	10.98	200.12	YES
19953	3.80	232.5	33.81	198.7	YES
19954	2.20	134.6	29.79	104.8	YES
19955	1.85	113.2	41.94	71.26	YES
19956	3.80	232.5	7.15	225.3	YES
19957	3.60	220.2	41.85	178.3	YES

Remarks:

I.J.I. Delaney

Dr. I. J. I. Delaney
Manager, Analytical Services

Dr. C. D. Desjardins
Head, Process Chemistry Department

REPORT NUMBER: PCAS/89/295 DATE: November 7, 1989

JOB NUMBER: 04000384/0722

PCAS CODES: 722-1, - 722-22 Page 2 of 2

TO: Neill Westall & Associates
Suite 207
8 King Street E.
Toronto, Ontario
M5C 1B5
Attn: Neill Westall & Jim Burns

Analysis of Waste Rock for Acid Producing Potential

Sample No.	% S	A Theoretical Acid Production lb/ton	B Acid Consumed lb/ton	A-B #4	Theor. Acid Producer
19958	2.30	140.7	52.92	87.78	YES
19959	2.00	122.4	29.89	92.51	YES
19960	3.00	183.5	50.76	132.7	YES
19961	3.10	189.7	51.16	138.5	YES
19962	1.00	61.18	53.70	7.48	YES
19963	1.50	91.77	46.26	45.51	YES
19964	2.40	146.8	52.63	94.17	YES
19965	1.50	91.77	69.48	22.29	YES
19966	1.00	61.18	46.84	14.34	YES
19967	2.00	122.4	55.17	67.23	YES
19968	1.60	97.89	63.11	34.78	YES
19969	1.80	110.1	65.76	44.34	YES

Remarks:

I.J.I. Delaney

Dr. I. J. I. Delaney
Manager, Analytical Services

Dr. C. D. Desjardins
Head, Process Chemistry Department

REPORT NUMBER: PC/89/361 DATE: December 1, 1989

JOB NUMBER: 04000384/0743

PCAS CODES: Page 1 of 5

TO:
Neil Westoll & Associates
Suite 207
8 King Street E.
Toronto, Ontario
M5C 1B5
Attn: Neil Westoll

Analysis of Waste Rock for Acid Producing Potential

Sample No. Cores	% S	A Theoretical Acid Production lb/ton	B Acid Consumed lb/ton	A-B #4	Theor. Acid Producer
19637	0.12	7.34	29.79	-22.45	NO
19638	0.10	6.12	28.71	-22.59	NO
19639	0.14	8.56	9.80	-1.24	NO
19640	0.06	3.67	15.78	-12.11	NO
19641	0.10	6.12	28.32	-22.20	NO
19642	0.22	13.46	38.71	-25.25	NO
19643	0.01	0.61	40.96	-40.35	NO
19644	0.03	1.83	39.40	-37.57	NO
19645	0.04	2.45	53.02	-50.57	NO
19646	0.15	9.18	53.12	-43.94	NO

Remarks:

I.J.I Delaney

Dr. I. J. I. Delaney
Manager, Analytical Services

Dr. C. D. Desjardins
Head, Process Chemistry Department

rpc

REPORT NUMBER: PC/89/361 DATE: December 1, 1989

JOB NUMBER: 04000384/0743

PCAS CODES: Page 2 of 5

TO:
Neil Westoll & Associates
Suite 207
8 King Street E.
Toronto, Ontario
M5C 1B5
Attn: Neil Westoll

Analysis of Waste Rock for Acid Producing Potential

Sample No.	% S	A Theoretical Acid Production lb/ton	B Acid Consumed lb/ton	A-B #4	Theor. Acid Producer
19647	1.03	63.01	44.39	18.62	YES
19648	0.10	6.12	33.32	-27.2	NO
19649	0.16	9.79	30.18	-20.39	NO
19650	0.13	7.95	30.28	-22.33	NO
19651	0.24	14.68	23.03	-8.35	NO
19970	0.85	52.00	14.11	37.89	YES
19971	2.02	123.6	17.84	105.8	YES
19972	3.21	196.4	18.52	177.8	YES
19973	1.69	103.4	68.21	35.19	YES

Remarks:

I. J. I. Delaney

Dr. I. J. I. Delaney
Manager, Analytical Services

Dr. C. D. Desjardins
Head, Process Chemistry Department

REPORT NUMBER: PC/89/361 DATE: December 1, 1989

JOB NUMBER: 04000384/0743

PCAS CODES: Page 3 of 5

TO:
Neil Westoll & Associates
Suite 207
8 King Street E.
Toronto, Ontario
M5C 1B5
Attn: Neil Westoll

Analysis of Waste Rock for Acid Producing Potential

Sample No. Cores	% S	A Theoretical Acid Production lb/ton	B Acid Consumed lb/ton	A-B #4	Theor. Acid Producer
19974	0.64	39.15	215.3	-176.2	NO
19975	0.17	10.40	102.4	-92.0	NO
19976	0.06	36.71	170.1	-133.4	NO
19977	0.07	4.28	101.8	-97.5	NO
19978	2.34	143.2	28.62	114.6	YES
19979	1.73	105.8	39.30	66.5	YES
19980	2.79	170.7	14.01	156.7	YES
19981	2.65	162.1	19.31	142.8	YES
19982	1.77	108.3	24.21	84.1	YES
19983	3.11	190.3	12.15	178.2	YES

Remarks:

I. J. I. Delaney

Dr. I. J. I. Delaney
Manager, Analytical Services

Dr. C. D. Desjardins
Head, Process Chemistry Department

REPORT NUMBER: PC/89/361 DATE: December 1, 1989

JOB NUMBER: 04000384/0743

PCAS CODES:

TO: Neil Westoll & Associates
Suite 207
8 King Street E.
Toronto, Ontario
M5C 1B5
Attn: Neil Westoll

Analysis of Waste Rock for Acid Producing Potential

Sample No.	% S	A Theoretical Acid Production lb/ton	B Acid Consumed lb/ton	A-B #4	Theor. Acid Producer
19984	1.47	89.93	18.91	71.02	YES
19985	1.67	102.2	13.43	88.77	YES
19986	1.76	107.7	23.91	83.79	YES
19987	1.28	78.3	28.32	49.98	YES
19988	0.34	20.80	29.69	-8.89	NO
19989	0.14	8.56	32.73	-24.17	NO
19990	0.15	9.18	25.97	-16.79	NO
19991	0.17	10.40	32.73	-22.33	NO
19992	0.08	4.89	85.46	-80.57	NO
19993	0.11	6.73	47.04	-40.31	NO

Remarks:

I.J.I. Delaney

Dr. I. J. I. Delaney
Manager, Analytical Services

Dr. C. D. Desjardins
Head, Process Chemistry Department

REPORT NUMBER: PC/89/361 DATE: December 1, 1989

JOB NUMBER: 04000384/0743

PCAS CODES:

TO:
Neil Westoll & Associates
Suite 207
8 King Street E.
Toronto, Ontario
M5C 1B5
Attn: Neil Westoll

Analysis of Waste Rock for Acid Producing Potential

Sample No.	% S	A Theoretical Acid Production lb/ton	B Acid Consumed lb/ton	A-B #4	Theor. Acid Producer
19994	0.06	3.67	49.98	-46.31	NO
19995	0.10	6.12	25.68	-19.56	NO
19996	0.14	8.56	40.08	-31.22	NO
19997	0.03	1.83	32.44	-30.61	NO
19998	0.04	2.45	24.50	-22.05	NO
19999	0.11	6.73	30.67	-23.94	NO

Remarks:

I. J. I. Delaney

Dr. I. J. I. Delaney
Manager, Analytical Services

Dr. C. D. Desjardins
Head, Process Chemistry Department

ACID GENERATION TESTS

Key to Samples

Sample No.	Drill Hole No.	Sample Location (Metres)
(Report PCAS/89/124)		
19401	MM-88-12	5 - 10
19402	"	10 - 15
19403	"	15 - 20
19404	"	20 - 25
19405	"	25 - 30
19406	"	30 - 35
19407	"	35 - 39.4
19408	"	39.4 - 45
19409	"	45 - 50
19410	"	50 - 55
19411	"	55 - 59.6
19412	"	59.6 - 65
19413	"	65 - 70
19414	"	70 - 75
19415	"	75 - 80
19416	"	80 - 85
19417	"	85 - 90
19418	"	90 - 96.12
19419	"	96.12 - 96.8
19420	MM-88-19	4.5 - 10
19421	"	10 - 15
19422	"	15 - 20
19423	"	20 - 25
19424	"	25 - 30
19425	"	30 - 35
19426	"	35 - 40
19427	"	40 - 47.45
19428	"	47.45 - 49.95

Acid Generation Tests
Key to Samples (continued)

Sample No.	Drill Hole No.	Sample Location (Metres)
19429	MM-88-41	4.9 - 10
19430	"	10 - 15
19431	"	15 - 20
19432	"	20 - 25.9
19433	"	25.9 - 30
19434	"	30 - 35
19435	"	35 - 40
19436	"	40 - 45
19437	"	45 - 50
19438	"	50 - 55
19439	"	55 - 60
19440	"	60 - 66.95
19441	"	66.95 - 70
19442	"	70 - 76
1401	MM-88-12	109.3 - 113.8
1402	"	113.8 - 118.3
1403	MM-88-19	49.95 - 55.95
1404	"	55.95 - 60.95
1405	"	60.95 - 66.95
1406	MM-88-41	76.0 - 80.75
1407	"	80.75 - 87.0
1408	"	87.0 - 93.0
1409	MM-88-57	5.2 - 10.5
1410	"	10.5 - 16.5
1411	"	16.5 - 22.5
1412	"	22.5 - 28.5
1413	"	28.5 - 34.5
1414	"	34.5 - 40.5
1415	"	40.5 - 46.5
1416	"	46.5 - 52.5
1417	"	52.5 - 58.4

Sample No.	Drill Hole No.	Sample Location (Metres)
1408	MM-88-22	14.1 - 18.6
1409	"	18.6 - 23.1
1420	"	23.1 - 26.5
1421	"	26.5 - 30.5
1422	"	30.5 - 35.0
1423	"	35.0 - 39.5
1424	"	39.5 - 43.45
1425	MM-88-75	5.0 - 10.5
1426	"	10.5 - 15.0
1427	"	15.0 - 19.0
1428	MM-89-98	7.55 - 12.0
1429	"	12.0 - 16.5
1430	"	16.5 - 21.0
1431	"	21.0 - 25.5
1432	"	25.5 - 30.55

(Report PCAS/89/295)

Sample No.	Drill Hole No.	Sample Location (Metres)
19948	MM-88-23	8.5 - 10.5
19949	"	10.5 - 15.0
19950	"	15.0 - 18.0
19951	"	18.0 - 21.8
19952	"	21.8 - 25.5
19953	"	25.5 - 30.0
19954	"	30.0 - 34.5
19955	"	34.5 - 39.0
19956	MM-88-25	4.0 - 9.0
19957	"	9.0 - 15.0
19958	"	15.0 - 19.5
19959	"	19.5 - 24.0
19960	"	24.0 - 28.5
19961	"	28.5 - 34.5
19962	"	34.5 - 39.0

Acid Generation Tests
Key to Samples (continued)

Sample No.	Drill Hole No.	Sample Location (Metres)
19963	MM-88-28	6.0 - 12.0
19964	"	12.0 - 17.0
19965	"	17.0 - 21.0
19966	"	21.0 - 25.5
19967	MM-88-29	7.0 - 12.0
19968	"	12.0 - 16.5
19969	"	16.5 - 21.0
(Report PC/89/361)		
19637	MM-89-115	1.8 - 4.9
19638	"	4.9 - 7.9
19639	"	7.9 - 10.9
19640	"	10.9 - 13.9
19641	"	13.9 - 16.9
19642	"	16.9 - 19.9
19643	"	19.9 - 22.9
19644	"	22.9 - 25.9
19645	"	25.9 - 30.2
19646	"	30.2 - 31.9
19647	"	31.9 - 34.9
19648	"	34.9 - 37.9
19649	"	37.9 - 40.9
19650	"	40.9 - 43.9
19651	"	43.9 - 45.9
19970	MM-89-112	5.48 - 7.9
19971	"	7.9 - 10.9
19972	"	10.9 - 13.9
19973	"	13.9 - 15.6
19974	"	15.6 - 17.3
19975	"	17.3 - 18.4
19976	"	18.4 - 22.35
19977	"	22.35 - 24.0

Acid Generation Tests
Key to Samples (continued)

Sample No.	Drill Hole No.	Sample Location (Metres)
19978	MM-89-113	3.66 - 4.9
19979	"	4.9 - 7.9
19980	"	7.9 - 10.9
19981	"	10.9 - 13.9
19982	"	13.9 - 16.9
19983	"	16.9 - 19.9
19984	"	19.9 - 22.9
19985	"	22.9 - 25.9
19986	"	25.9 - 28.9
19987	"	28.9 - 31.9
19788	MM-89-114	3.66 - 4.9
19789	"	4.9 - 7.9
19790	"	7.9 - 10.9
19791	"	10.9 - 13.9
19792	"	13.9 - 16.9
19793	"	16.9 - 19.9
19794	"	19.9 - 22.9
19795	"	22.9 - 25.9
19796	"	25.9 - 28.9
19797	"	28.9 - 31.9
19798	"	31.9 - 34.9
19799	"	34.9 - 36.9

APPENDIX D

TEST PIT LOGS AND SOIL SAMPLE TESTS

GEMTEC LIMITED
GROUND ENGINEERING & MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.	**JOB No.:** 286.01	TP 1	
PROJECT: Environmental Impact Assessment	**DATE:** 890503	**PAGE:** 1 of 1	
LOCATION: Restigouche Project, N.B.			
GROUND SFC. ELEV.	**DATUM:**		

DEPTH m	SAMPLE No.	SAMPLE TYPE	N	LOG	DESCRIPTION	ELEV. m	WATER
0					Brown silty SAND, some gravel, numerous roots	0.22	
	1	G			Brown clayey silty SAND & GRAVEL some cobbles and boulders	0.61	
1					BEDROCK Fracture spacing very close - very weak		
2	2	G			Fracture spacing & strength increase with depth		
	3	G				2.59	
3					End of Test Pit at 2.59 m Groundwater table not encountered		
4							

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

TEST PIT LOG

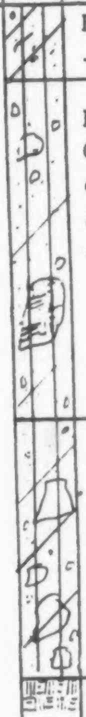
CLIENT: Marshall Minerals Corp.	JOB No.: 286.01	TP 2
PROJECT: Environmental Impact Assessment	DATE: 890502	PAGE: 1 of 1
LOCATION: Restigouche Project, N.B.		
GROUND SFC. ELEV.	DATUM:	

DEPTH m	SAMPLE No.	SAMPLE TYPE	N	LOG	DESCRIPTION	ELEV. m	WATER
0	1	G			Grey silty SAND & GRAVEL -numerous roots	0.15	
	2	G			Brown silty SAND & GRAVEL -numerous roots	0.30	
	3	G			BEDROCK joint spacing 1"± moderate strength	0.61	
					End of Test Pit at 0.61 m		
1					Groundwater table not encountered		
2							
3							
4							

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.		JOB No.: 286.01	TP3
PROJECT: Environmental Impact Assessment		DATE: 890502	PAGE: 1 of 1
LOCATION: Restigouche Project, N.B.			
GROUND SFC. ELEV.	DATUM:		



DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. m	WATER
0	1	G			Brown clayey silty SAND -some gravel & roots	0.22	
					Brown silty SAND & GRAVEL, numerous cobbles, some boulders and small amount of clay		
1						1.22	
	2	G			Brown clayey silty SAND & GRAVEL, numerous cobbles & boulders		▼
						1.98	
2					End of Test Pit on bedrock at 1.98 m Groundwater table encountered at 1.83 m		
3							
4							

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.	JOB No.: 286.01	TP 4	
PROJECT: Environmental Impact Assessment	DATE: 890502	PAGE: 1 of 1	
LOCATION: Restigouche Project, N.B.			
GROUND SFC. ELEV.	DATUM:		

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. m	WATER
0					Brown silty SAND with gravel, numerous roots	0.21	
	1	G			Brown silty SAND & GRAVEL, some clay	0.61	
					BEDROCK	0.79	
1					End of Test Pit at 0.79 m Groundwater table not encountered.		
2							
3							
4							

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.		**JOB No.:** 286.01	TP 5
PROJECT: Environmental Impact Assessment		**DATE:** 890502	**PAGE:** 1 of 1
LOCATION: Restigouche Project, N.B.			
GROUND SFC. ELEV.	**DATUM:**		

DEPTH m	SAMPLE No.	SAMPLE TYPE	N	LOG	DESCRIPTION	ELEV. m	WATER
0					100 mm brown TOPSOIL grey to brown silty SAND some gravel-numerous roots		
	1	G				0.30	
					BEDROCK		
	2	G			joint spacing very close -moderate to strong		
						0.91	
1					End of Test Pit at 0.91 m Groundwater table not encountered		
2							
3							
4							

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.	**JOB No.:** 286.01	TP 6	
PROJECT: Environmental Impact Assessment	**DATE:** 890502	**PAGE:** 1 of 1	
LOCATION: Restigouche Project, N.B.			
GROUND SFC. ELEV.	**DATUM:**		

DEPTH m	SAMPLE No.	SAMPLE TYPE	N	LOG	DESCRIPTION	ELEV. m	WATER
0					Black to brown organic sandy SILT-numerous roots	0.31	
	1	G			Brown clayey silty SAND and GRAVEL -cobbles as depth increases		
1							
2							
3					End of Test Pit at 3.66 m.		
	2	G				3.66	
4					Water seeping from sides of excavation at 0.9 m probably from ponded water		

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.		**JOB No.:** 286.01	TP 7
PROJECT: Environmental Impact Assessment		**DATE:** 890502	**PAGE:** 1 of 1
LOCATION: Restigouche Project, N.B.			
GROUND SFC. ELEV.	**DATUM:**		

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. m	WATER
0					Brown silty SAND and GRAVEL-organic matter in top 200 mm	0.31	
					BEDROCK	0.91	
1					End of Test Pit at 0.91 m Groundwater table not encountered		
2							
3							
4							

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.		JOB No.: 286.01	TP 8
PROJECT: Environmental Impact Assessment		DATE: 890502	PAGE: 1 of 1
LOCATION: Restigouche Project, N.B.			
GROUND SFC. ELEV.	DATUM:		

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. m	WATER
0					Brown silty SAND & GRAVEL-numerous roots	0.24	
					BEDROCK	0.76	
					End of Test Pit at 0.76 m Groundwater table not encountered		
1							
2							
3							
4							

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.		JOB No.: 286.01	TP 9
PROJECT: Environmental Impact Assessment		DATE: 890502	PAGE: 1 of 1
LOCATION: Restigouche Project, N.B.			
GROUND SFC. ELEV.	DATUM:		

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. m	WATER
0					Black to brown silty SAND & GRAVEL	0.37	
	1	G			BEDROCK joint spacing very close -to close-moderate to strong	0.79	
1					End of Test Pit at 0.79 m Groundwater table not encountered		
2							
3							
4							

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.

JOB No.: 286.01

TP 10

PROJECT: Environmental Impact Assessment

DATE: 890502

PAGE: 1 of 1

LOCATION: Restigouche Project, N.B.

GROUND SFC. ELEV.

DATUM:

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. m	WATER
0					Brown silty SAND & GRAVEL organic matter in top 150 mm	0.25	
	1	G			Brown SAND & GRAVEL -numerous cobbles -small amount of clay	0.61	
	2	G			BEDROCK -joint spacing very close to close - moderate to strong	0.91	▼
1					End of Test Pit at 0.91 m		
2							
3							
4							

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.	**JOB No.:** 286.01	TP 11
PROJECT: Environmental Impact Assessment	**DATE:** 890502	**PAGE:** 1 of 1
LOCATION: Restigouche Project, N.B.		
GROUND SFC. ELEV.	**DATUM:**	

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. m	WATER
0					Grey to brown silty SAND & GRAVEL-numerous roots	0.30	
	1	G			Brown silty SAND-some gravel	0.61	
					BEDROCK	0.91	
1					End of Test Pit at 0.91 m Groundwater table not encountered		
2							
3							
4							

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.		**JOB No.:** 286.01	TP 12
PROJECT: Environmental Impact Assessment		**DATE:** 890502	**PAGE:** 1 of 1
LOCATION: Restigouche Project, N.B.			
GROUND SFC. ELEV.	**DATUM:**		

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. m	WATER
0					Grey to brown silty SAND & GRAVEL-numerous roots	0.27	
					Brown SAND & GRAVEL -numerous cobbles	0.61	
					BEDROCK	0.76	
					End of Test Pit at 0.76 m Groundwater table not encountered		
1							
2							
3							
4							

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.		**JOB No.:** 286.01	TP 13
PROJECT: Environmental Impact Assessment		**DATE:** 890502	**PAGE:** 1 of 1
LOCATION: Restigouche Project, N.B.			
GROUND SFC. ELEV.	**DATUM:**		

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. m	WATER
0					100 mm TOPSOIL Grey to brown silty SAND, some gravel numerous roots		
	1	G				0.30	
					BEDROCK -joint spacing very close-moderate to strong		
	2	G				0.91	
1					End of Test Pit at 0.91 m Groundwater table not encountered		
2							
3							
4							

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.	**JOB No.:** 286.01	TP 14
PROJECT: Environmental Impact Assessment	**DATE:** 890503	**PAGE:** 1 of 1
LOCATION: Restigouche Project, N.B.		
GROUND SFC. ELEV.	**DATUM:**	

DEPTH m	SAMPLE No.	SAMPLE TYPE	N	LOG	DESCRIPTION	ELEV. m	WATER
0	1	G			100mm brown TOPSOIL grey to brown silty SAND some gravel-numerous roots	0.25	
	2	G			Brown silty SAND & GRAVEL -numerous cobbles, some boulders and some clay.	0.91	
1					End of Test Pit at 0.91 m. Groundwater table not encountered		
2							
3							
4							

GEMTEC LIMITED
GROUND ENGINEERING & MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.		**JOB No.:** 286.01	TP 15
PROJECT: Environmental Impact Assessment		**DATE:**	**PAGE:** 1 of 1
LOCATION: Restigouche Project, N.B.			
GROUND SFC. ELEV.	**DATUM:**		

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. m	WATER
0					Black to brown silty SAND & GRAVEL	0.25	
					BEDROCK	0.91	
1					End of Test Pit at 0.91 m Groundwater table not encountered		
2							
3							
4							

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.
JOB No.: 286.01
TP 16
PROJECT: Environmental Impact Assessment
DATE: 890503
PAGE: 1 of 1
LOCATION: Restigouche Project, N.B.
GROUND SFC. ELEV.
DATUM:

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. m	WATER
0					Black to brown silty SAND-some gravel-numerous roots	0.25	
	1	G			Brown SAND & GRAVEL numerous cobbles	0.91	
1					BEDROCK	1.52	
2					End of Test Pit at 1.52 m Groundwater table not encountered		
3							
4							

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.	**JOB No.:** 286.01	TP 17	
PROJECT: Environmental Impact Assessment	**DATE:** 890503	**PAGE:** 1 of 1	
LOCATION: Restigouche Project, N.B.			
GROUND SFC. ELEV.	**DATUM:**		

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. m	WATER
0					Black to brown silty SAND, some gravel	0.22	
					Brown SAND & GRAVEL- numerous cobbles	0.48	
					BEDROCK	1.06	
1					End of Test Pit at 1.06 m Groundwater table not encountered		
2							
3							
4							

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.	**JOB No.:** 286.01	TP 18	
PROJECT: Environmental Impact Assessment	**DATE:** 890503	**PAGE:** 1 of 1	
LOCATION: Restigouche Project, N.B.			
GROUND SFC. ELEV.	**DATUM:**		

DEPTH m	SAMPLE No.	SAMPLE TYPE	N	LOG	DESCRIPTION	ELEV. m	WATER
0	1	G			GRAVEL & COBBLES 80% with silty sand 20%	0.22	
					Orange-brown silty fine to medium SAND- occasional gravel & cobble particles		
1							
	2	G					
2							
3							
	3	G				3.65	
4	4	S			Gravel & cobbles 70% with silty sand 30%	4.11	
	5	G			Greyish brown BEDROCK -weak, joint spacing very close too close	4.72	▼
5					End of Test Pit at 4.72 m		
6							
7							
8							

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.	**JOB No.:** 286.01	TP 19	
PROJECT: Environmental Impact Assessment	**DATE:** 890503	**PAGE:** 1 of 1	
LOCATION: Restigouche Project, N.B.			
GROUND SFC. ELEV.	**DATUM:**		

DEPTH m	SAMPLE No.	SAMPLE TYPE	N	LOG	DESCRIPTION	ELEV. m	WATER
0					Black to brown silty SAND-some gravel, numerous roots	0.30	
	1	G			Brown silty SAND & GRAVEL	0.73	
	2	G			BEDROCK		
1					Brown to yellow rock has consistency of very stiff clay		
	3	G					
2							
3						3.05	
	4	G			Rock turns to grey and increases in strength to very weak		
4					End of Test Pit at 3.96 m. G.W.T. not encountered	3.96	

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.		**JOB No.:** 286.01	TP 20
PROJECT: Environmental Impact Assessment		**DATE:** 890503	**PAGE:** 1 of 1
LOCATION: Restigouche Project, N.B.			
GROUND SFC. ELEV.	**DATUM:**		

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. m	WATER
0				▨	Greyish green weathered BEDROCK		
	1	G			-excavation by backhoe changes it to sand & gravel with some silt		
1							
2							
					End of Test Pit at 2.74 m Groundwater table not encountered	2.74	
3							
4							

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.		**JOB No.:** 286.01	TP 21
PROJECT: Environmental Impact Assessment		**DATE:** 890503	**PAGE:** 1 of 1
LOCATION: Restigouche Project, N.B.			
GROUND SFC. ELEV.	**DATUM:**		

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. m	WATER
0	1	G			BEDROCK Joint spacing very close to close, moderate to strong	0.61	
					End of Test Pit at 0.61 m. Groundwater table not encountered		
1							
2							
3							
4							

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.		**JOB No.:** 286.01	TP 23
PROJECT: Environmental Impact Assessment		**DATE:** 890503	**PAGE:** 1 of 1
LOCATION: Restigouche Project, N.B.			
GROUND SFC. ELEV.	**DATUM:**		

DEPTH m	SAMPLE No.	SAMPLE TYPE	N	LOG	DESCRIPTION	ELEV. m	WATER
0	1	G			Black organic sandy SILT-roots	0.45	
	2	G			Greyish brown silty SAND & GRAVEL - some clay & cobbles	0.91	
1	3	G			BEDROCK - joint spacing very close, moderate to strong	1.21	
					End of Test Pit at 1.21 m Groundwater table not encountered		
2							
3							
4							

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.		**JOB No.:** 286.01	TP 25
PROJECT: Environmental Impact Assessment		**DATE:** 890503	**PAGE:** 1 of 1
LOCATION: Restigouche Project, N.B.			
GROUND SFC. ELEV.	**DATUM:**		

DEPTH m	SAMPLE No.	SAMPLE TYPE	N	LOG	DESCRIPTION	ELEV. m	WATER
0					Brown silty SAND & GRAVEL FILL		
	1	G					
						0.91	
1	2	G			Black to brown organic silty SAND-some clay & gravel	1.10	
	3	G			Very weak BEDROCK grey to blue		
2							
						2.53	
					End of Test Pit at 2.53 m Groundwater table not encountered		
3							
4							

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

TEST PIT LOG

CLIENT: Marshall Minerals Corp.	**JOB No.:** 286.01	TP 26	
PROJECT: Environmental Impact Assessment	**DATE:** 890503	**PAGE:** 1 of 1	
LOCATION: Restigouche Project, N.B.			
GROUND SFC. ELEV.	**DATUM:**		

DEPTH m	SAMPLE No.	SAMPLE TYPE	N	LOG	DESCRIPTION	ELEV. m	WATER
0					Black to brown silty SAND-some gravel-numerous roots	0.25	
	1	G			Brown silty SAND -some gravel -cobbles		
1						1.21	
	2	G			Red to grey weathered BEDROCK -has consistency of very stiff clay -becomes harder with depth		
2						2.59	
					End of Test Pit at 2.59 m Groundwater table not encountered		
3							
4							

GEMTEC LIMITED
GEOTECHNICAL ENGINEERING
& MATERIALS TECHNOLOGY

LABORATORY DATA

MARSHALL
MINERALS
CORP.

LOCATION: RESTIGOUCHE DEPOSIT N.B. | PROJECT: 286.01 | SHEET 1 OF 4

SAMPLE DATA			DESCRIPTION OF SOIL TEXTURE		CONSISTENCY LIMITS		MECHANICAL ANALYSIS								
Test Pit No.	Sample No.	Depth of Sample, metres		NATURAL WATER CONTENT w	LIQUID LIMIT w_L	PLASTIC LIMIT w_P	CLAY SIZE (<0.002-5 mm)	SILT SIZE (0.002 - 0.080 mm)	SAND SIZE (0.080 - 5 mm)	GRAVEL SIZE (5 - 80 mm)		UNDRAINED SHEAR STR. (Qu/2)	UNDRAINED SHEAR STR. (PP)	UNDRAINED SHEAR STRENGTH (VANE)	ORGANIC CONTENT %
				%								KPa			
1	1	0.4	Bn. Clayey silty S & G some C & B	28.9	46	32	HYDROM 17 36.2	19	29	35	ML &OL				
	2	1.8	Rx												
	3	2.5	Rx												
2	1	0.1	Gy silty S & G numerous roots	18.2											
	2	0.2	Bn silty S & G numerous roots	27.4			12		51	37					
	3	0.5	Rx												
3	1	0.2	Bn silty S & G, num C some B, [trace] clay	29.3			37.7		38	24					
	2	1.5	Bn clayey silty S & G numerous C & B	12.8			25.7		26	48					
4	1	0.4	Bn silty S & G some clay	11.7	25.3	17.9	HYDROM 12 36	14	36	28	CL-ML				
5	1	0.2	Gy-Bn silty S, some G numerous roots	30.8			16.7		49	34					
	2	0.7	Rx												

GEMTEC LIMITED
GROUND ENGINEERING & MATERIALS TECHNOLOGY

LABORATORY DATA

MARSHALL
MINERALS
CORP.

LOCATION: RESTIGOUCHE DEPOSIT N.B. PROJECT: 286.01 SHEET 2 OF 4

SAMPLE DATA			DESCRIPTION OF SOIL TEXTURE	NATURAL WATER CONTENT	CONSISTENCY LIMITS		MECHANICAL ANALYSIS								
Test Pit No.	Sample No.	Depth of Sample, metres			LIQUID LIMIT	PLASTIC LIMIT	CLAY SIZE (<0.002-.5 mm)	SILT SIZE (0.002 - 0.080 mm)	SAND SIZE (0.080 - 5 mm)	GRAVEL SIZE (5 - 80 mm)		UNDRAINED SHEAR STR. (Qu/2)	UNDRAINED SHEAR STR. (PP)	UNDRAINED SHEAR STRENGTH (VANE)	ORGANIC CONTENT %
				w	w_l	w_P									
				%								KPa			
6	1	0.5	Bn clayey silty S & G	24.2	33	20.3	HYDROM 9 42.2	33	37	21	CL				
	2	3.6	Bn clayey silty S & G	16.2	29.1	20.0	HYDROM 10 26.6	17	42	31	CL				
9	1	0.6	Rx												
10	1	0.5	Bn S & G, numerous C [trace] clay	14.1			20.6		31	48					
	2	0.8	Rx												
11	1	0.5	Bn silty S, some G	43.5			18.1		68	14					
13	1	0.2	Gy to Bn S & G, some silt, some G, num. roots	30.3			15.8		36	48					
	2	0.7	Rx												
14	1	0.2	Gy to Bn sandy gravel, some silt numerous roots	29.1			15.3		34	51					
	2	0.5	Bn silty S & G, numerous C, some B, [trace] clay	12.2			31.6		36	32					
16	1	0.5	Bn S & G, numerous C												

GEMTEC LIMITED GROUND ENGINEERING & MATERIALS TECHNOLOGY	LABORATORY DATA	MARSHALL MINERALS CORP.
LOCATION: RESTIGOUCHE DEPOSIT N.B.	PROJECT: 286.01	SHEET 3 OF 4

SAMPLE DATA			DESCRIPTION OF SOIL TEXTURE	NATURAL WATER CONTENT	CONSISTENCY LIMITS		MECHANICAL ANALYSIS								
Test Pit No.	Sample No.	Depth of Sample, metres		w	LIQUID LIMIT w_l	PLASTIC LIMIT w_p	CLAY SIZE (<0.002-5 mm)	SILT SIZE (0.002 - 0.080 mm)	SAND SIZE (0.080 - 5 mm)	GRAVEL SIZE (5 - 80 mm)		UNDRAINED SHEAR STR. (Qu/2)	UNDRAINED SHEAR STR. (PP)	UNDRAINED SHEAR STRENGTH (VANE)	ORGANIC CONTENT %
				%								KPa			
18	1	0.2	80% G & C 20% Silty S	21.0											
	2	1.2	Orange-Bn gravely sand& silt occ. G & C	34.4				39.9	36	24					
	3	3.3	Silty SAND, some GRAVEL	37.8				35.0	54	11					
	4	3.9	70% G & C 30% Silty sand	33.6											
	5	4.4	Gy-Bn Rx												
19	1	0.5	Bn silty S & G	20.9											
	2	0.9	Rx-[stiff clay-like] weathered	20.2											
	3	1.5	Rx-[stiff clay-like] weathered	15.4											
	4	3.2	Rx												
20	1	1.0	Gy-green weathered Rx												
21	1	0.3	Rx												

GEMTEC LIMITED
GEOTECHNICAL ENGINEERING
& MATERIALS TECHNOLOGY

LABORATORY DATA

MARSHALL
MINERALS
CORP.

LOCATION: RESTIGOUCHE DEPOSIT N.B. | PROJECT: 286.01 | SHEET 4 OF 4

SAMPLE DATA			DESCRIPTION OF SOIL TEXTURE	NATURAL WATER CONTENT	CONSISTENCY LIMITS		MECHANICAL ANALYSIS								
Test Pit No.	Sample No.	Depth of Sample, metres			LIQUID LIMIT	PLASTIC LIMIT	CLAY SIZE (<0.002-5 mm)	SILT SIZE (0.002 - 0.080 mm)	SAND SIZE (0.080 - 5 mm)	GRAVEL SIZE (5 - 80 mm)		UNDRAINED SHEAR STR. (Cu/2)	UNDRAINED SHEAR STR. (PP)	UNDRAINED SHEAR STRENGTH (VANE)	ORGANIC CONTENT %
				w	w_l	w_p									
				%								KPa			
23	1	0.3	Bk organic sandy silt [with] roots	386.2											
	2	0.7	Gy-Bn silty S & G some clay & C	29.7											
	3	1.1	Rx												
25	1	0.4	Bn silty S & G FILL	15.4											
	2	1.0	Bk-Bn organic silty S, some clay & G	36.5											
	3	1.3	Gy-Blue V-Weak Rx												
26	1	0.5	Bn silty S, some G, cobbles	21.1			27.7								
	2	1.4	Red-Gy weathered Rx [stiff clay-like]	20.6											

APPENDIX E

ROCK QUALITY DESIGNATION ANALYSIS

ROCK QUALITY DATA

MINERAL EXPLORATION HOLE 88-1

Start Metres	End Metres	Average Depth, m	Run mm	Recovery mm	Length >100mm	Recovery %	RQD %
3.10	3.66	3.4	560	500	0	89	0
3.66	5.20	4.4	1540	1700	300	110	19
5.20	7.35	6.3	2150	1950	850	91	40
7.35	8.20	7.8	850	870	730	102	86
8.20	11.28	9.7	3080	3200	800	104	26
11.28	11.35	11.3	70	50	0	71	0
11.35	14.33	12.8	2980	2350	700	79	23
14.33	16.30	15.3	1970	1950	250	99	13
16.30	17.37	16.8	1070	1050	870	98	81
17.37	20.42	18.9	3050	3050	3000	100	98
20.42	20.70	20.6	280	300	300	107	107
20.70	23.47	22.1	2770	2750	2750	99	99
23.47	25.15	24.3	1680	1650	1500	98	89
25.15	26.52	25.8	1370	1370	1350	100	99
26.52	29.50	28.0	2980	3000	2920	101	98
29.50	29.57	29.5	70	100	0	143	0
29.57	32.61	31.1	3040	2950	2800	97	92
32.61	33.46	33.0	850	1320	1320	155	155
33.46	35.60	34.5	2140	1610	1460	75	68
35.60	38.57	37.1	2970	2850	2460	96	83
38.57	38.71	38.6	140	150	150	107	107
38.71	41.76	40.2	3050	3100	2400	102	79
41.76	42.90	42.3	1140	1130	1050	99	92
42.90	44.81	43.9	1910	1920	1800	101	94
44.81	46.46	45.6	1650	2500	2500	152	152
46.46	47.85	47.2	1390	1410	1200	101	86
47.85	50.72	49.3	2870	3000	1640	105	57

MINERAL EXPLORATION HOLE 88-99

Start Metres	End Metres	Average Depth, m	Run mm	Recovery mm	Length >100mm	Recovery %	RQD %
15.00	18.00	16.5	3000	1400	630	47	21
18.00	21.00	19.5	3000	3000	1330	100	44
21.00	21.50	21.3	500	600	200	120	40
21.50	24.00	22.8	2500	2450	1850	98	74
24.00	26.75	25.4	2750	2900	1920	105	70
26.75	27.00	26.9	250	220	180	88	72
27.00	30.00	28.5	3000	2820	2100	94	70
30.00	32.35	31.2	2350	2600	1600	111	68
32.35	33.00	32.7	650	75	0	12	0
33.00	36.00	34.5	3000	3050	1820	102	61
36.00	38.60	37.3	2600	2450	1760	94	68
38.60	39.00	38.8	400	400	130	100	33
39.00	42.00	40.5	3000	3220	2420	107	81
42.00	44.00	43.0	2000	2000	1500	100	75
44.00	45.00	44.5	1000	1030	880	103	88
45.00	48.00	46.5	3000	3100	1500	103	50
48.00	49.10	48.6	1100	1600	250	145	23

MINERAL EXPLORATION HOLE 88-15

Start Metres	End Metres	Average Depth, m	Run mm	Recovery mm	Length >100mm	Recovery %	RQD %
5.49	8.23	6.9	2740	1100	400	40	15
8.23	10.50	9.4	2270	2700	550	119	24
10.50	11.28	10.9	780	830	340	106	44
11.28	14.33	12.8	3050	2900	1040	95	34
14.33	14.55	14.4	220	200	0	91	0
14.55	17.37	16.0	2820	1400	680	50	24
17.37	18.80	18.1	1430		1050	0	73
18.80	20.42	19.6	1620	1550	600	96	37
20.42	23.00	21.7	2580	2700	1400	105	54
23.00	23.47	23.2	470	400	400	85	85
23.47	26.52	25.0	3050	3150	2000	103	66
26.52	27.05	26.8	530	450	100	85	19
27.05	29.57	28.3	2520	2570	2000	102	79
29.57	31.25	30.4	1680	1760	1410	105	84
31.25	32.61	31.9	1360	1350	900	99	66
32.61	35.43	34.0	2820	2800	1460	99	52
35.43	35.66	35.5	230	250	130	109	57
35.66	38.71	37.2	3050	2710	2250	89	74
38.71	39.50	39.1	790	900	750	114	95
39.50	41.76	40.6	2260	2000	1350	88	60
41.76	43.65	42.7	1890	1900	1420	101	75
43.65	44.81	44.2	1160	1150	600	99	52
44.81	47.85	46.3	3040	2900	2050	95	67
47.85	47.90	47.9	50	50	0	100	0
47.90	50.90	49.4	3000	3100	2050	103	68
50.90	52.10	51.5	1200	1200	820	100	68

MINERAL EXPLORATION HOLE 88-44

Start Metres	End Metres	Average Depth, m	Run mm	Recovery mm	Length >100mm	Recovery %	RQD %
8.60	9.00	8.8	400	300	0	75	0
9.00	12.00	10.5	3000	3000	200	100	7
12.00	13.30	12.7	1300	1300	220	100	17
13.30	15.00	14.2	1700	1250	180	74	11
15.00	18.45	16.7	3450	3600	840	104	24
18.45	21.00	19.7	2550	2550	550	100	22
21.00	23.85	22.4	2850	3300	800	116	28
23.85	24.00	23.9	150	150	0	100	0
24.00	27.00	25.5	3000	3250	800	108	27
27.00	29.45	28.2	2450	2400	1550	98	63
29.45	30.00	29.7	550	570	320	104	58
30.00	33.00	31.5	3000	3100	2440	103	81
33.00	35.05	34.0	2050	2100	1757	102	86
35.05	36.00	35.5	950	950	900	100	95
36.00	39.00	37.5	3000	2800	850	93	28
39.00	40.40	39.7	1400	1600	600	114	43

APPENDIX F

WELL LOGS

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

WELL LOG

CLIENT: Marshall Minerals Corp.		DATE: 88/06/07	WELL NO. A
PROJECT: Restigouche Deposit		ELEV. m	PIEZOM. / Casing / PAGE 1 of 1
PROJECT NUMBER: 286.01	SURFACE ELEVATION: m	DATUM: Assumed	

DEPTH Metres / feet	SAMPLE NO	SAMPLE TYPE	N Blows per 300 mm	REC cm	CONTAM	LOG	DESCRIPTION
0							3.66 m OVERBURDEN
							Medium orange-brown color. Cuttings mainly felsic volcanics, rhyolite tuffs. Occasional Qtz cutting. (Qtz viens?) 14.5 m
							Slightly greyish orange-brown, cuttings darker than above, still volcanics (Rhyodacite?). Occ. lighter rhyolitic cutting.
							Medium grey-green color cuttings mainly rhyodacite/dacite. 46.5 m
							Greyish orange-brown color, cuttings 70 % grey-black Rhyodocite/dacite , 30% light to medium orange-brown, rhyolitic. 57.0 m
							Light to medium grey, rhyodacite. Occasional quartz (Qtz viens?) 62.5 m
							Black color, massive fine grained sulfides. 77.12 m
							End of hole at 77.12 m 6.71 m of 150 mm Ø casing installed, stick-up 0.28 m.
100							

Stick up -0.28

Shear Strength 10 20 KPa
Moisture Content × 10 20 %
Blows per 150 mm • 10 20

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

WELL LOG

CLIENT: Marshall Minerals Corp.	DATE: 88/06/07	WELL NO. B
PROJECT: Restigouche Deposit	ELEV. m / PIEZOM. / Casing	PAGE 1 of 1
PROJECT NUMBER: 286.01	SURFACE ELEVATION: m	DATUM: Assumed

DEPTH Metres	DEPTH feet	SAMPLE NO	SAMPLE TYPE	N Blows per 300 mm	REC cm	CONTAM	LOG	DESCRIPTION

Shear Strength 10 20 KPa

Moisture Content % 10 20 %

Blows per 150 mm • 10 20

Stick up -0.28

Depth (Metres): 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

3.66 m

Medium to dark brown cuttings, felsic and intermediate volcanics.

15.0 m

Grey to dark grey-black, felsic and intermediate volcanics, dacite, diabase? rhyodacite.

24.0 m

Black dacite/diabase?

33.5 m

Light grey color

Felsic volcanics, occasional dark cutting, diabase?

44.0

Grey to greyish black Intermediate to felsic volcanics.

55.0 m

Dark grey-black color massive sulphides.

76.92 m

End of hole at 76.92 m

6.48 m of 150 mm 0 casing installed, stick up 0.28 m

GEMTEC LIMITED
GROUND ENGINEERING
& MATERIALS TECHNOLOGY

WELL LOG

CLIENT: Marshall Minerals Corp.		DATE: 88/06/07	WELL NO. C
PROJECT: Restigouche Deposit		ELEV. m	PAGE 1 of 1
PROJECT NUMBER: 286.01	SURFACE ELEVATION: m	DATUM: Assumed	

DEPTH Metres	DEPTH feet	SAMPLE NO	SAMPLE TYPE	N Blows per 300 mm	REC cm	CONTAM	LOG	DESCRIPTION
0								OVERBURDEN 5 m±
								Light to medium brown cuttings, felsic volcanics. Rhyolite tuffs (brecciated), some sulphides. 14.0 m
10								
								Dark grey to black color, grey-fine grained volcanic rock with/without sulphides.
20								
30								
40								
50								
60								61.31 m
								End of hole at 61.31 m 6.46 m of 150 mm Ø casing installed, stick-up 0.216 m.
70								
80								
90								
100								

ELEV. m	PIEZOM.	Casing
	Stick up -0.46m	
	6.0 m	

Shear Strength 10 20 KPa
Moisture Content × 10 20 %
Blows per 150 mm • 10 20

APPENDIX G

RESULTS OF PUMP TESTING

PUMP TEST DATA - Summary of Figures

FIGURE NO.	PUMPED WELL	PUMP RATE igpm	OBSERV WELL	PERIOD	GRAPH TYPE
A 1	A	5.43	A	Pumping	Log-Time vs. Drawdown
A 2	A	5.43	A	Pumping	Time vs Drawdown
A 3	A	5.43	A	Recovery	Residual Drawdown
A 4	A	5.43	88-1	Pumping	Log-Time vs. Drawdown
A 5	A	5.43	88-1	Pumping	Time vs Drawdown
A 6	A	5.43	88-1	Recovery	Residual Drawdown
A 7	A	5.43	80-9	Pumping	Log-Time vs. Drawdown
A 8	A	5.43	80-9	Pumping	Time vs Drawdown
A 9	A	5.43	80-9	Recovery	Residual Drawdown
A 10	A	13.68	A	Pumping	Log-Time vs. Drawdown
A 11	A	13.68	A	Pumping	Time vs Drawdown
A 12	A	13.68	A	Recovery	Residual Drawdown
A 13	A	13.68	88-1	Pumping	Log-Time vs. Drawdown
A 14	A	13.68	88-1	Pumping	Time vs Drawdown
A 15	A	13.68	88-1	Recovery	Residual Drawdown
A 16	A	13.68	80-9	Pumping	Log-Time vs. Drawdown
A 17	A	13.68	80-9	Pumping	Time vs Drawdown
A 18	A	13.68	80-9	Recovery	Residual Drawdown
A 19	C	10.34	C	Pumping	Log-Time vs. Drawdown
A 20	C	10.34	C	Pumping	Time vs Drawdown
A 21	C	10.34	C	Recovery	Residual Drawdown
A 22	C	10.34	88-15	Pumping	Log-Time vs. Drawdown
A 23	C	10.34	88-15	Pumping	Time vs Drawdown
A 24	C	10.34	88-15	Recovery	Residual Drawdown
A 25	B	2.55	B	Pumping	Log-Time vs. Drawdown
A 26	B	2.55	B	Pumping	Time vs Drawdown
A 27	B	2.55	B	Recovery	Residual Drawdown
A 28	B	2.55	88-3	Pumping	Log-Time vs. Drawdown
A 29	B	2.55	88-3	Pumping	Time vs Drawdown

FIGURE A1

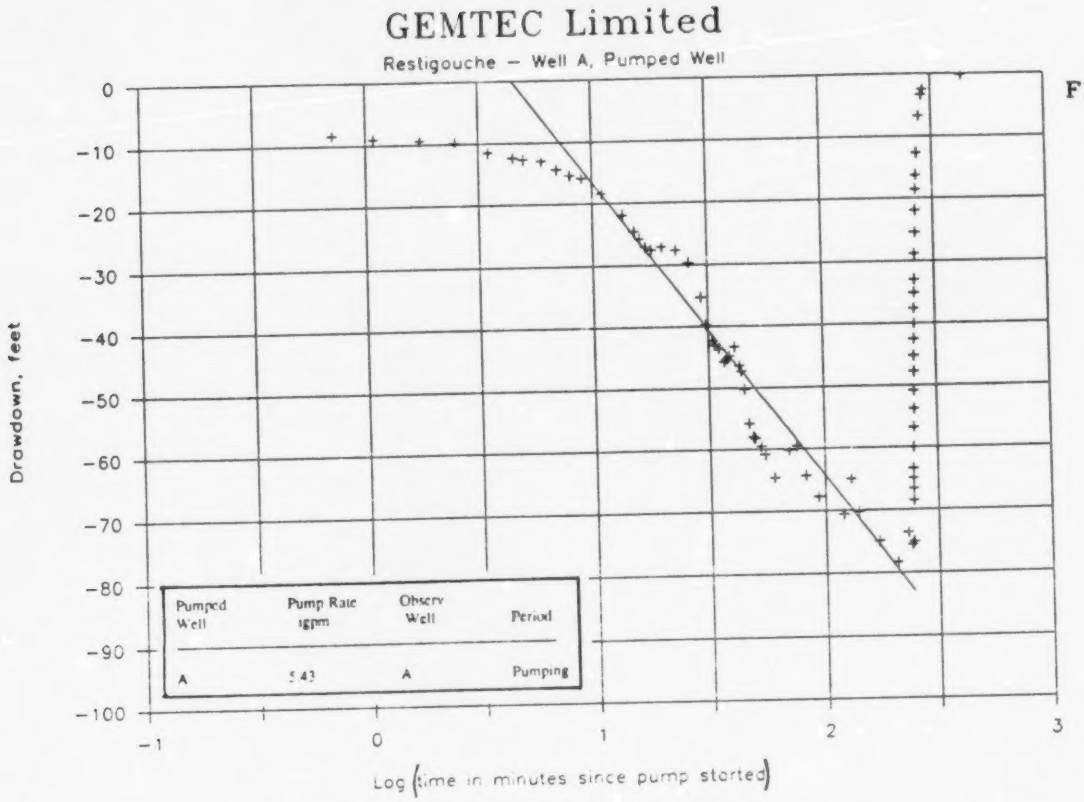
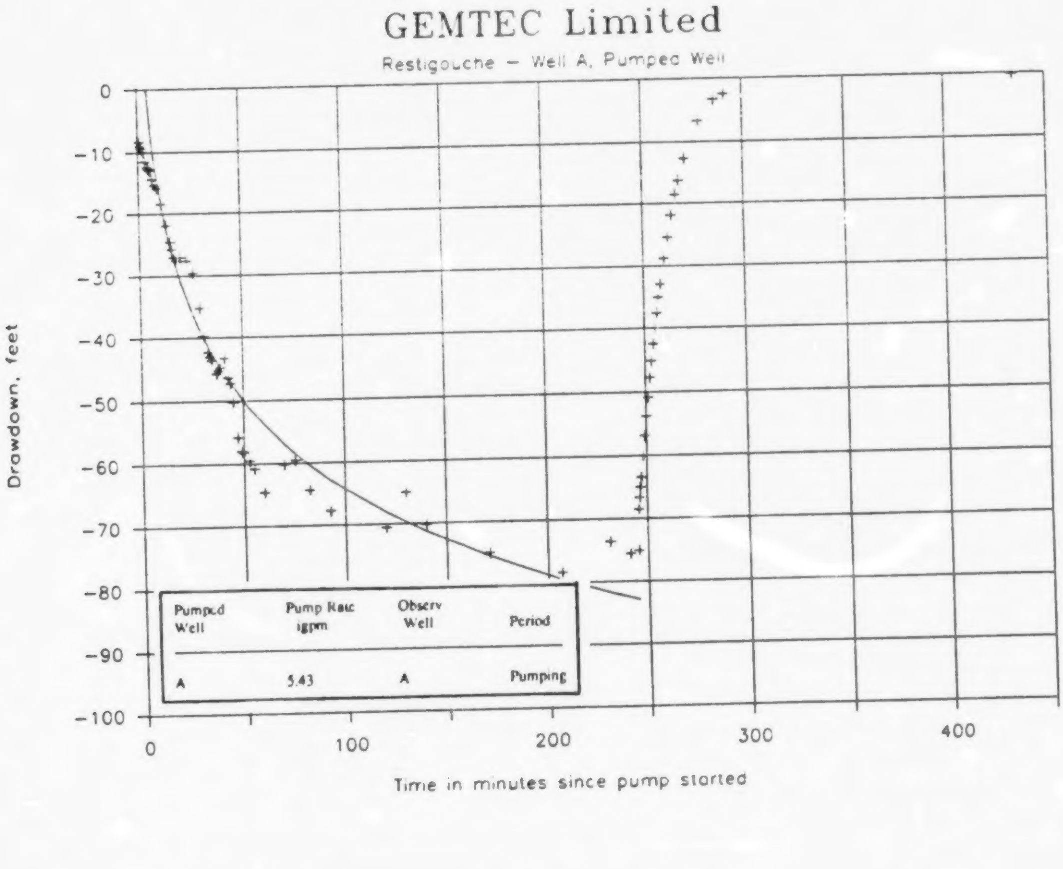


FIGURE A2



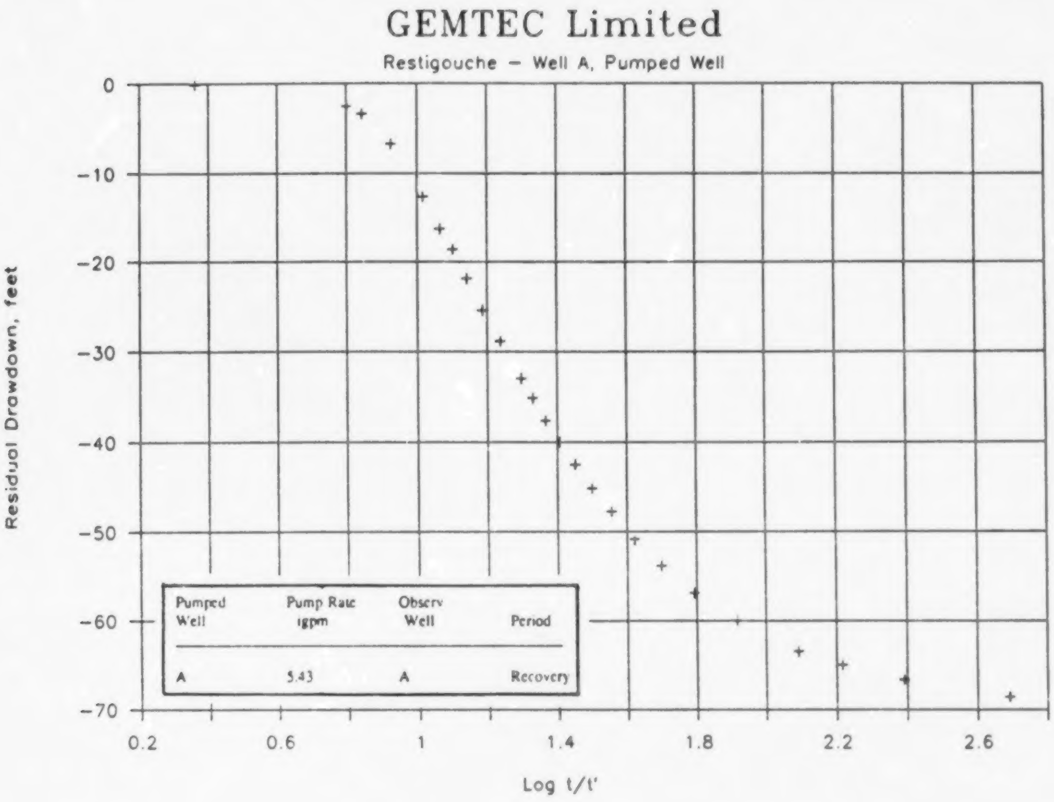


FIGURE A3

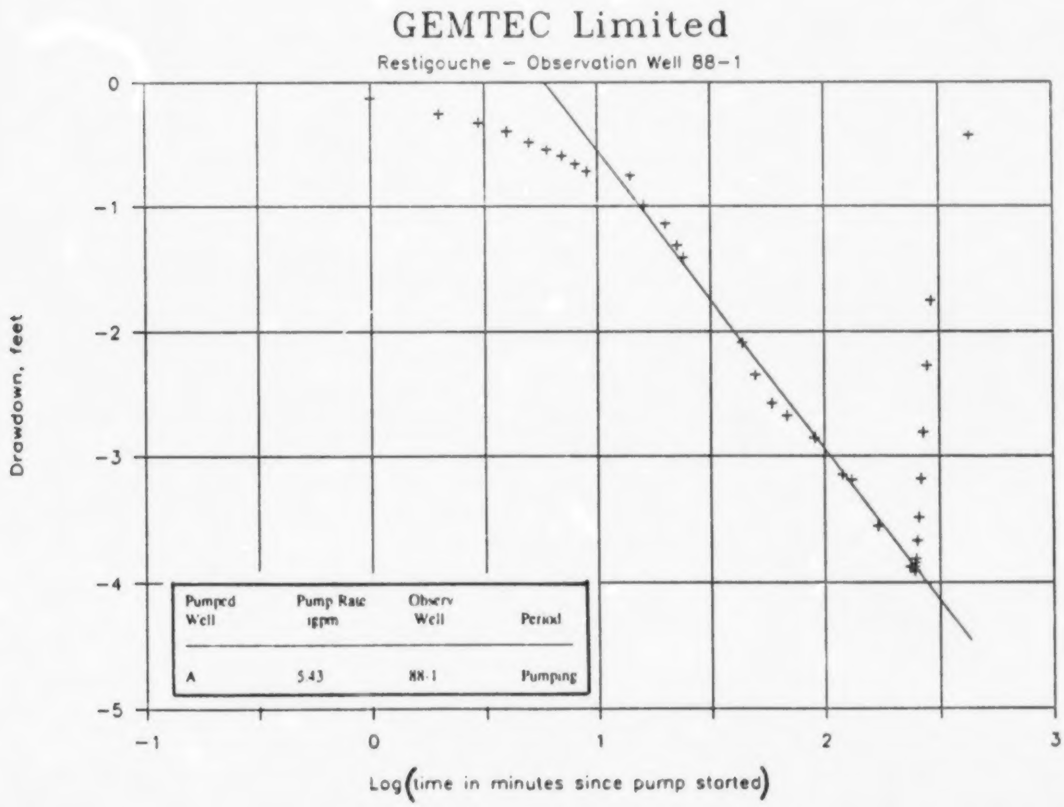


FIGURE A4

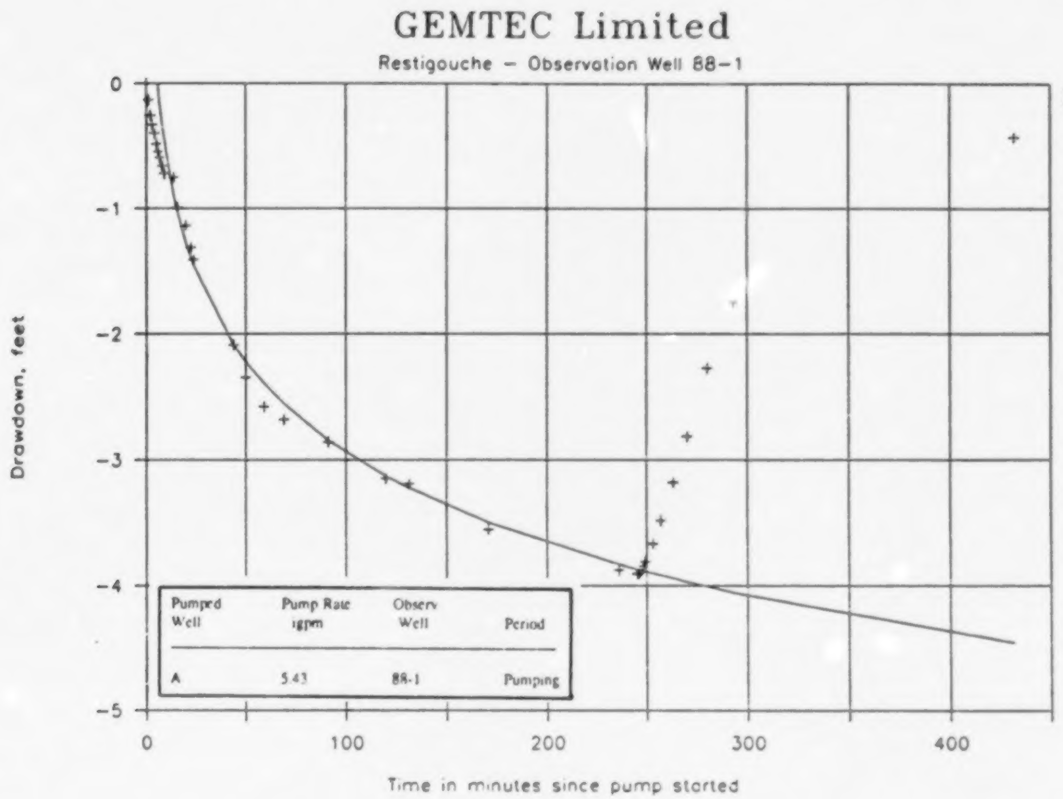


FIGURE A5

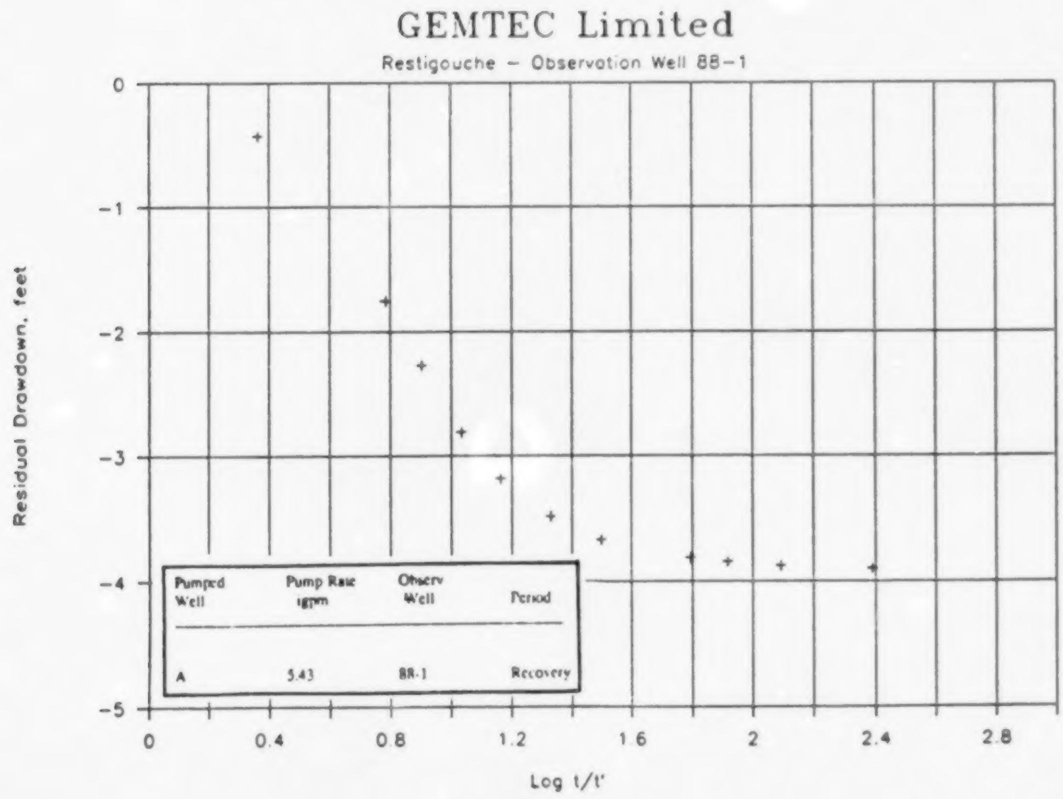


FIGURE A6

FIGURE A7

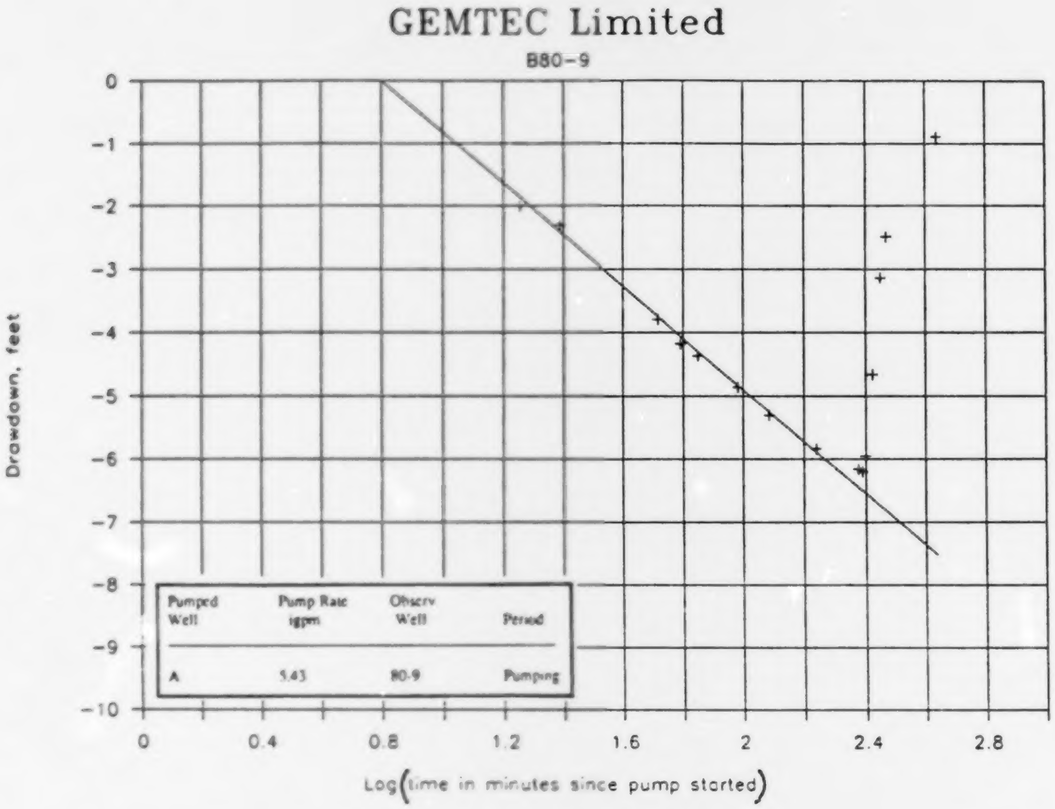
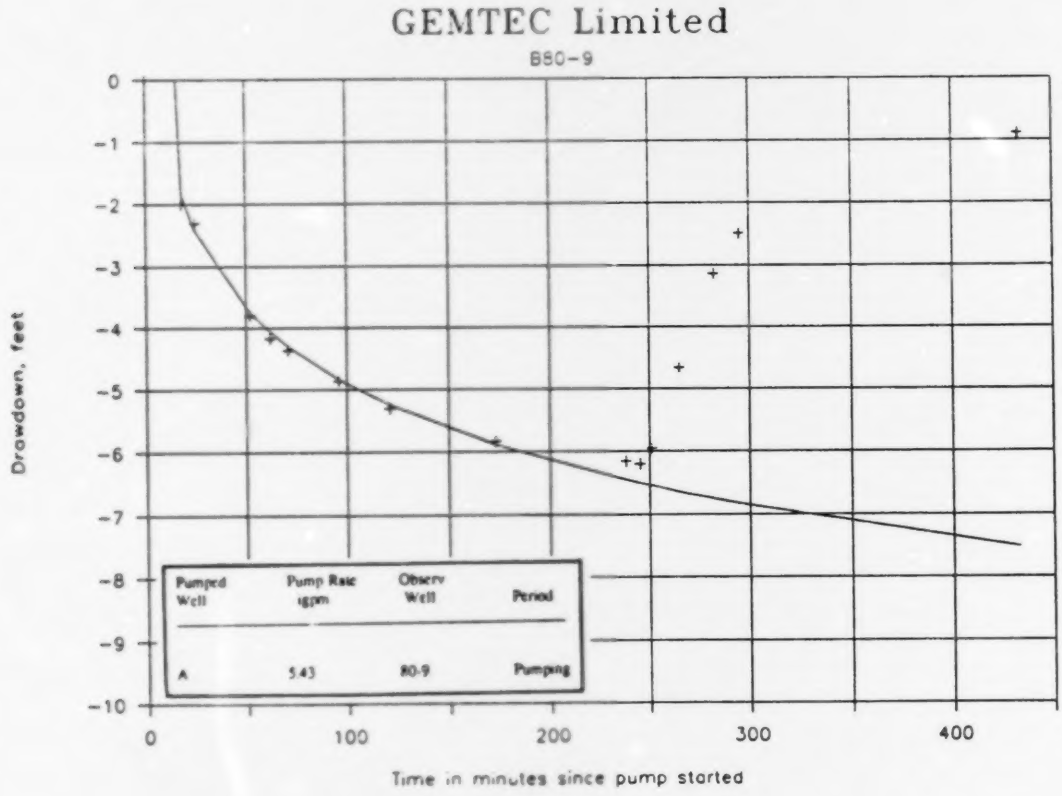
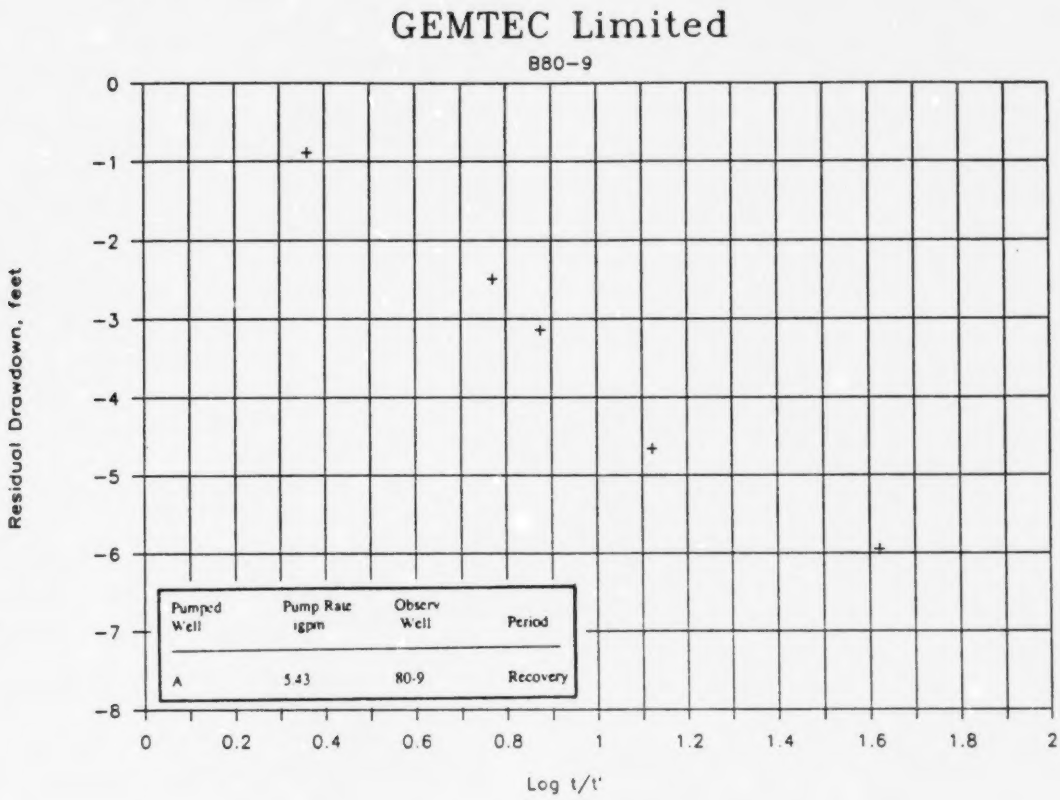


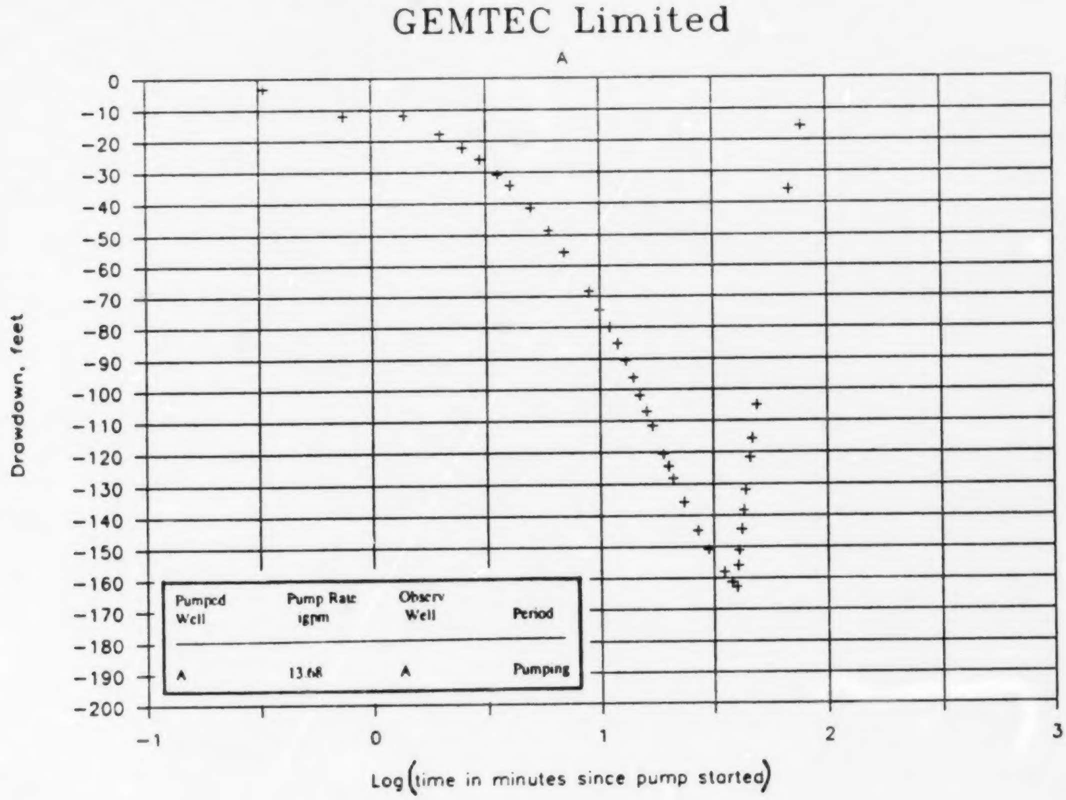
FIGURE A8




GEMTEC Limited

B80-9

FIGURE A9


GEMTEC Limited

A

FIGURE A10

FIGURE A11

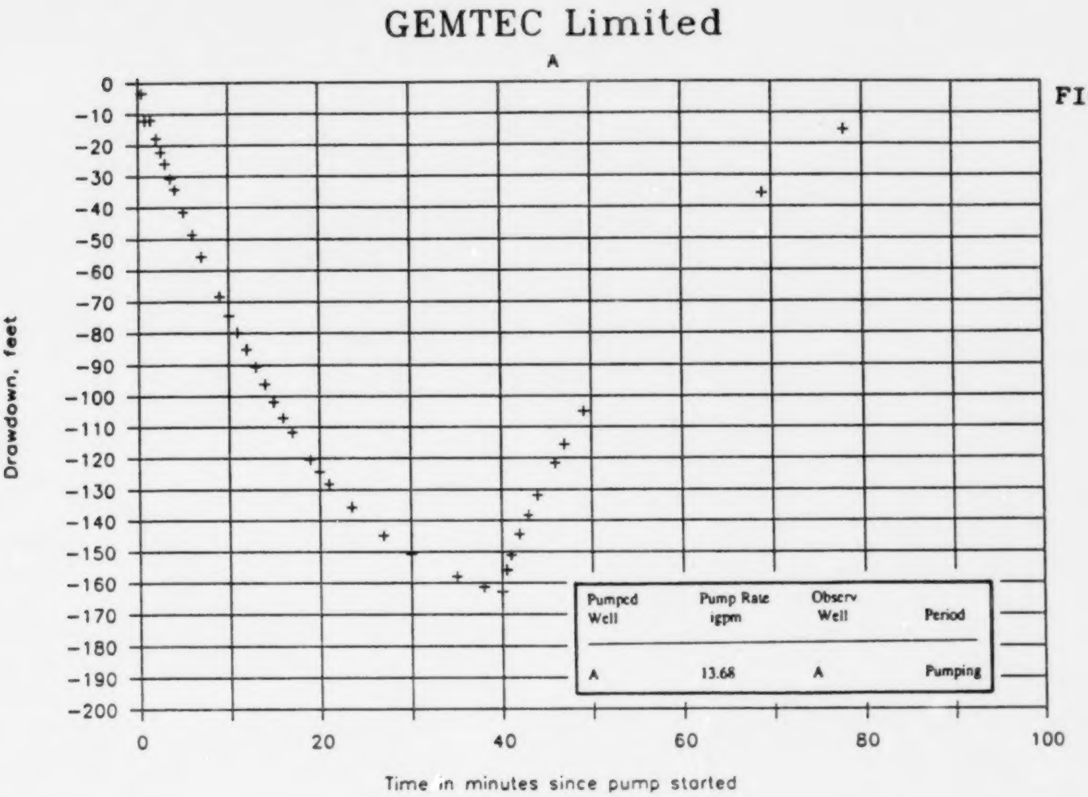
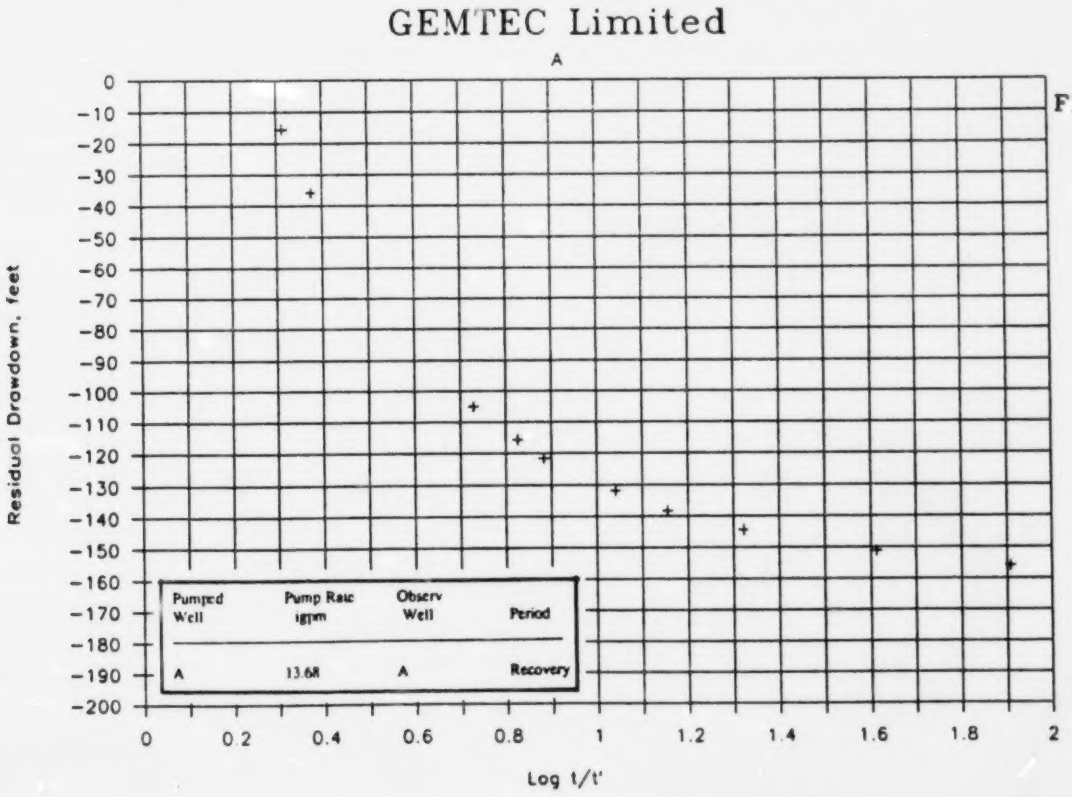


FIGURE A12



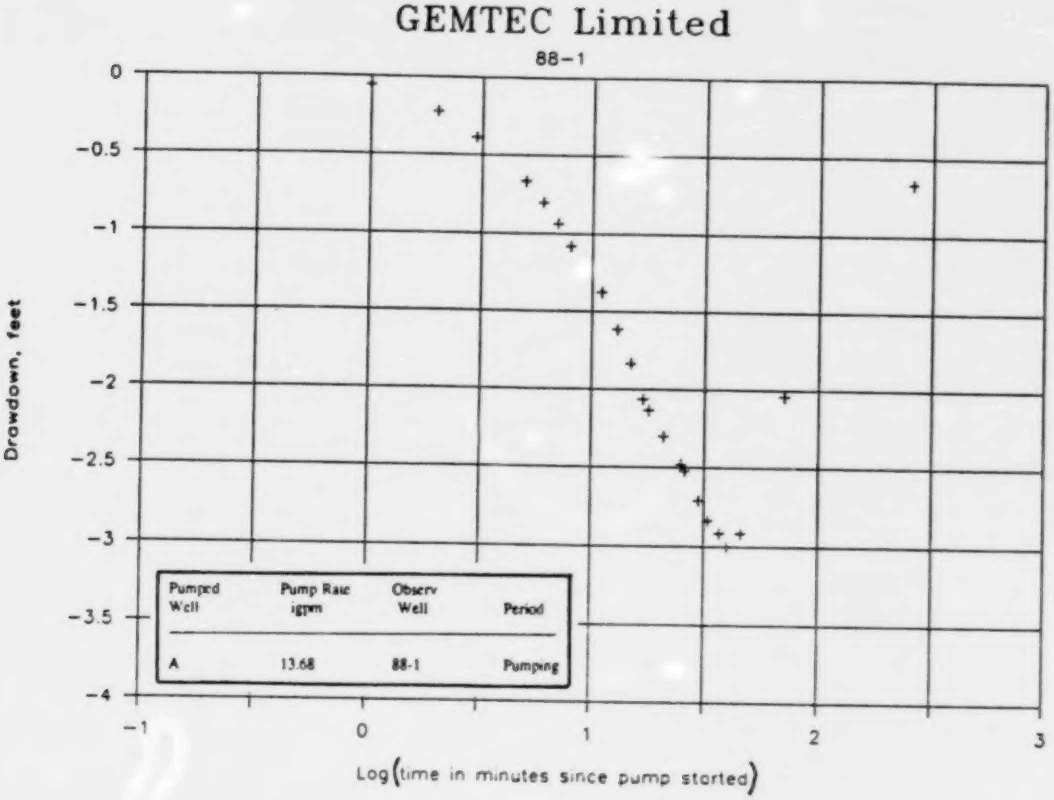


FIGURE A13

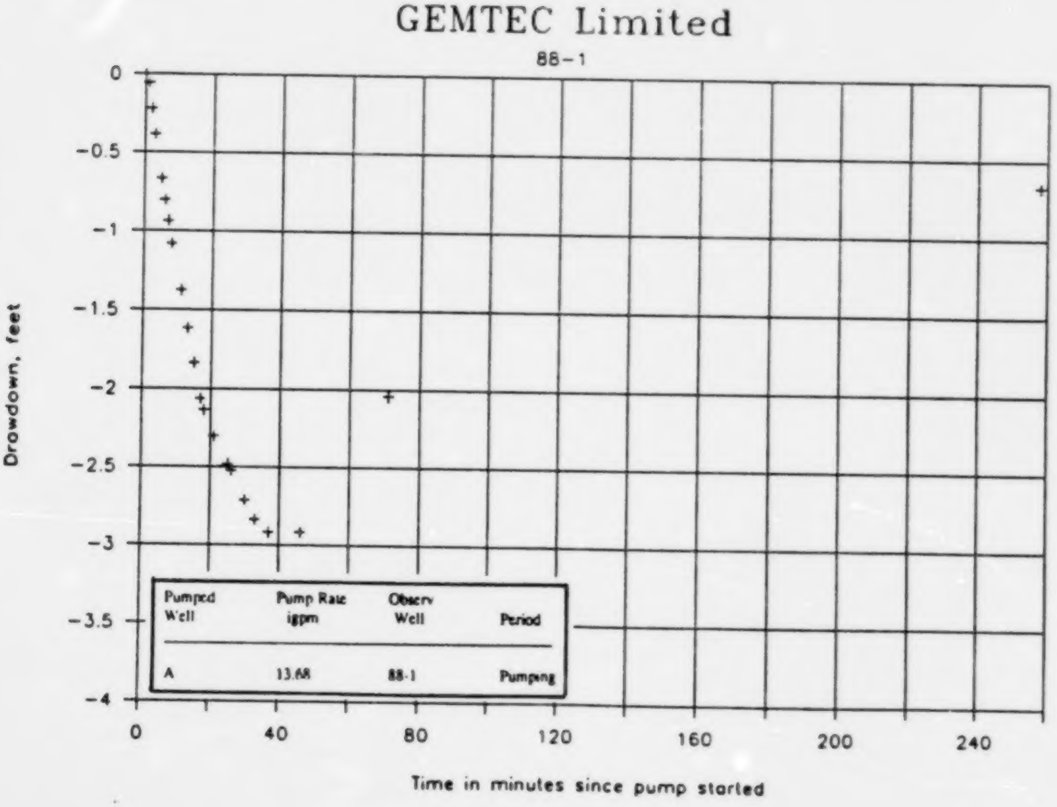


FIGURE A14

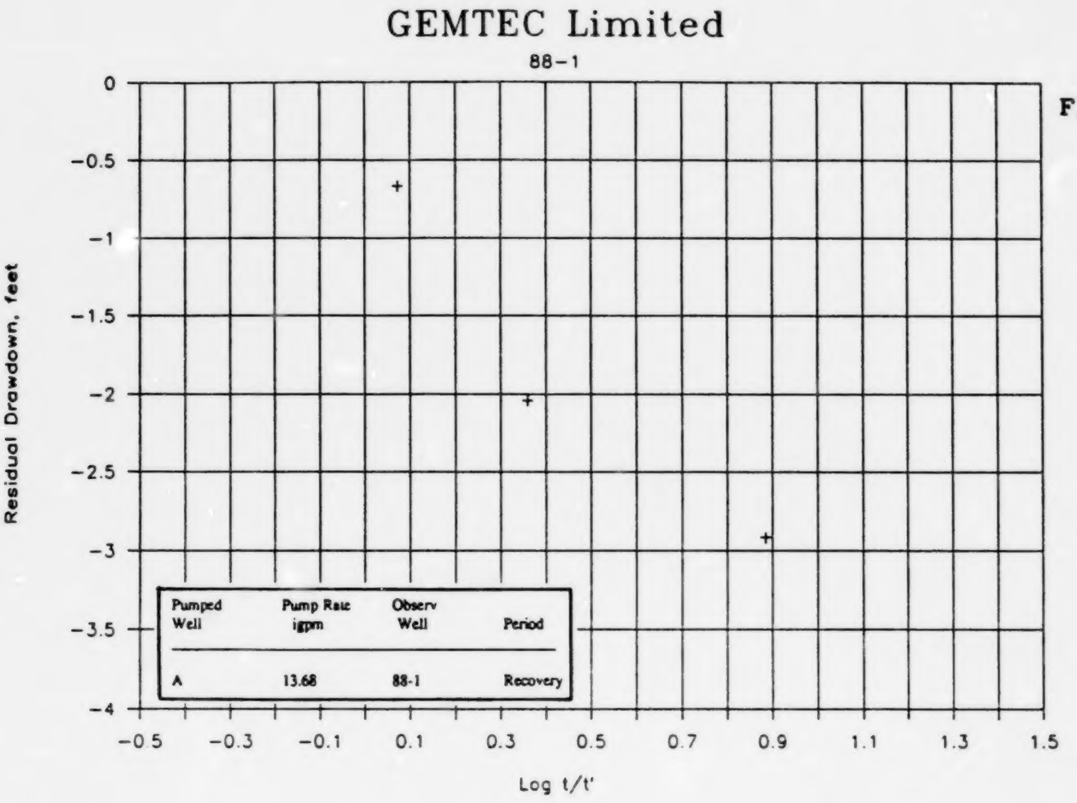


FIGURE A15

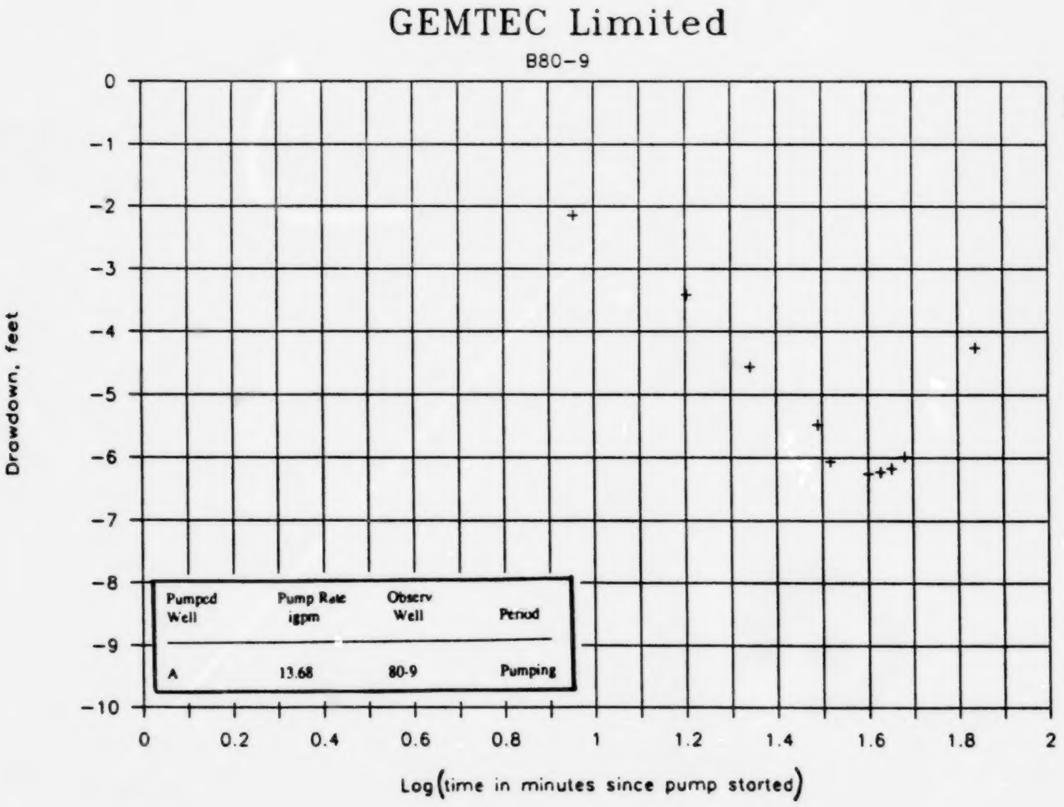


FIGURE A16

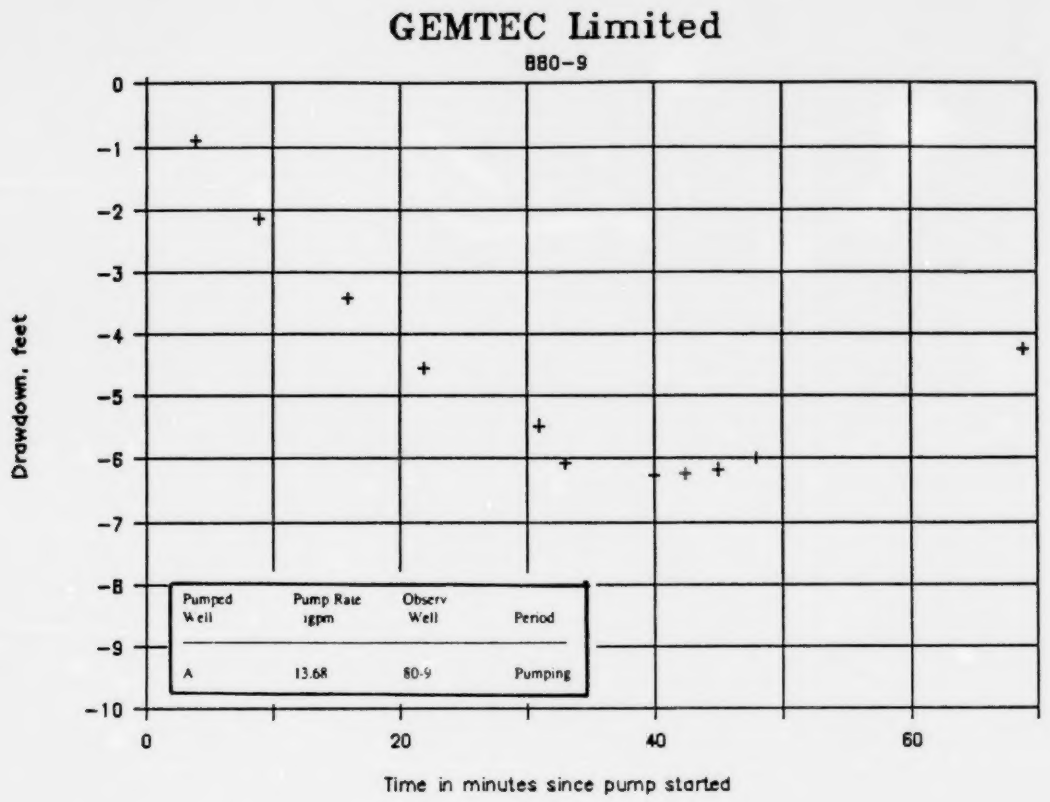


FIGURE A17

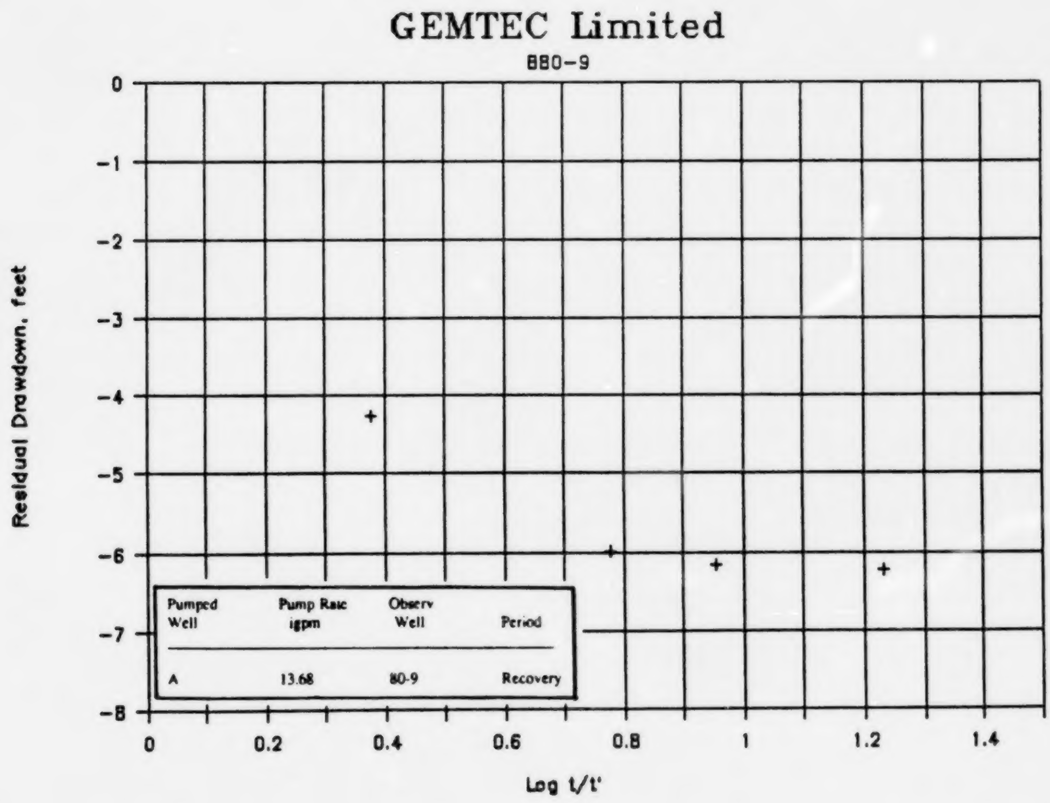
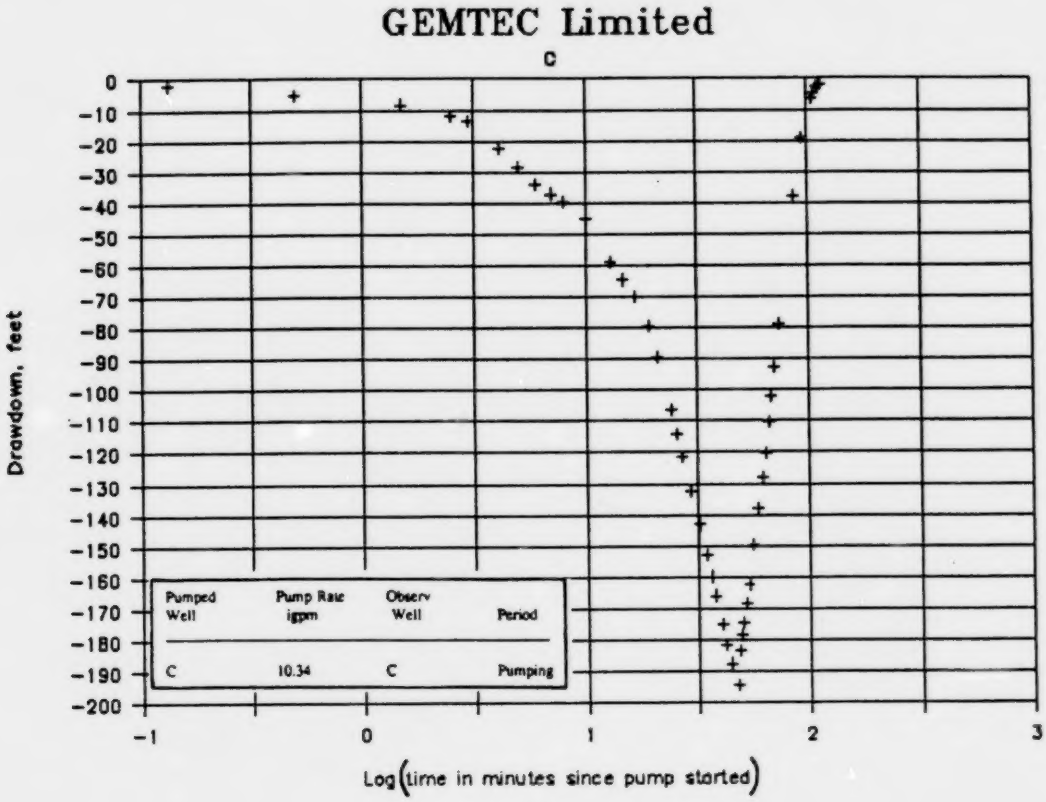


FIGURE A18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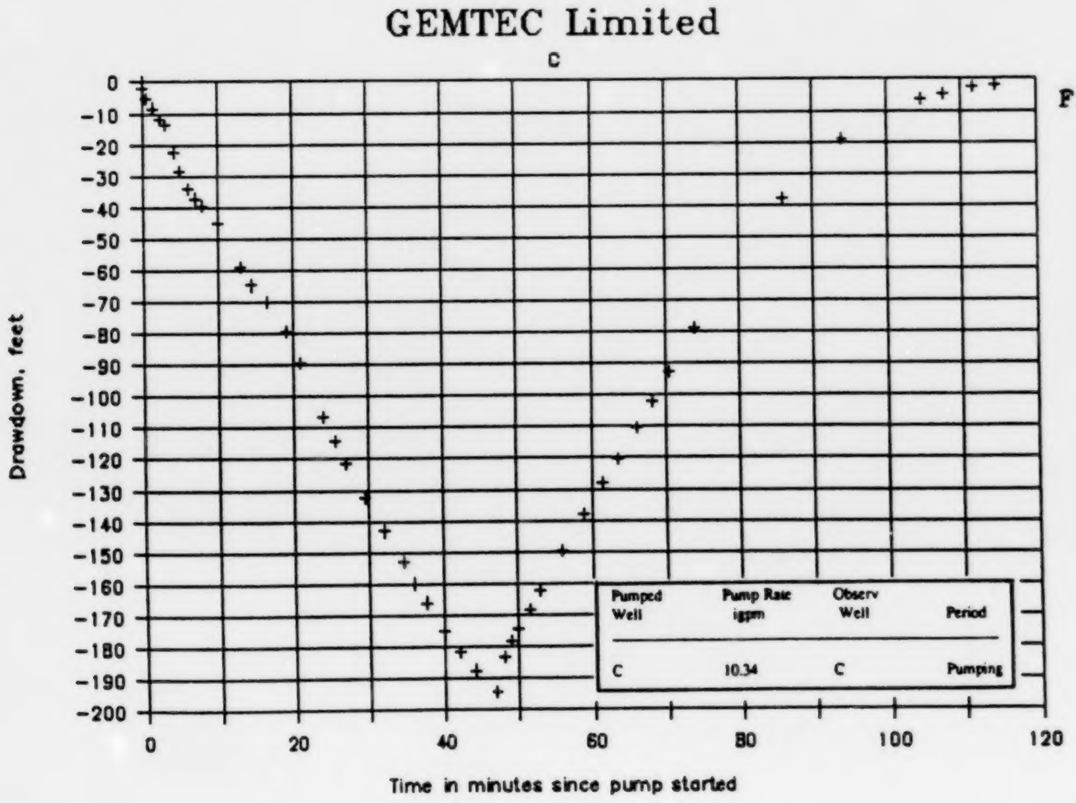
C

FIGURE A19


GEMTEC Limited

C

FIGURE A20

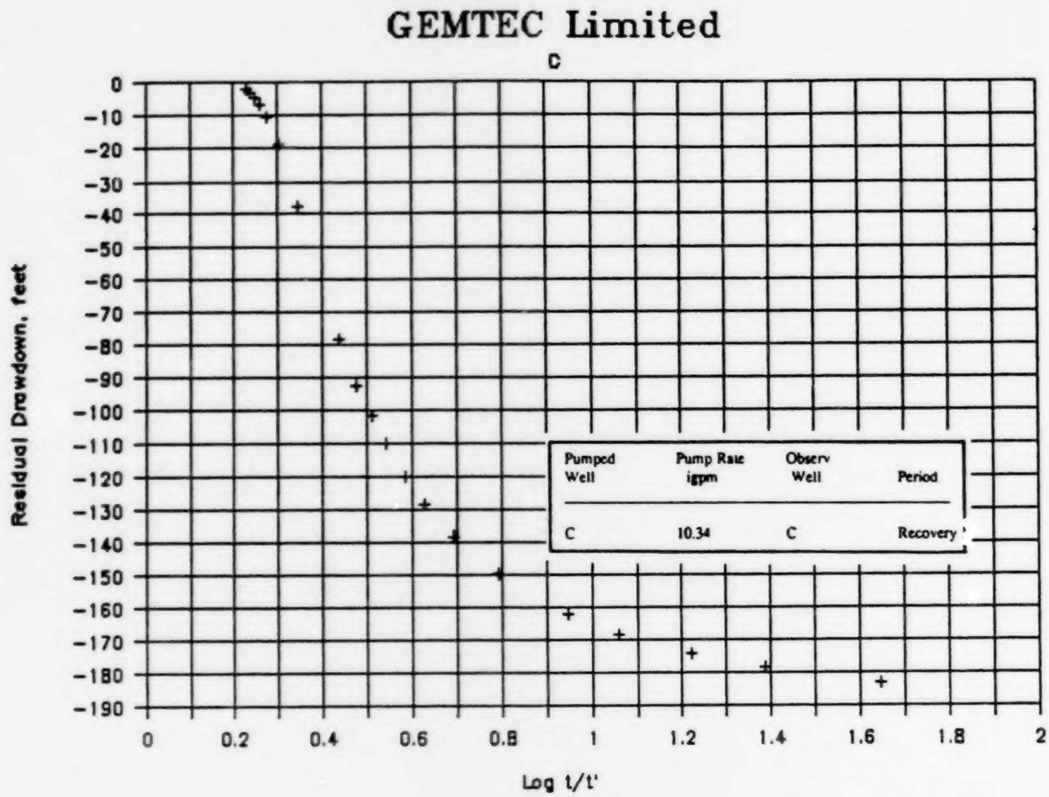


FIGURE A21

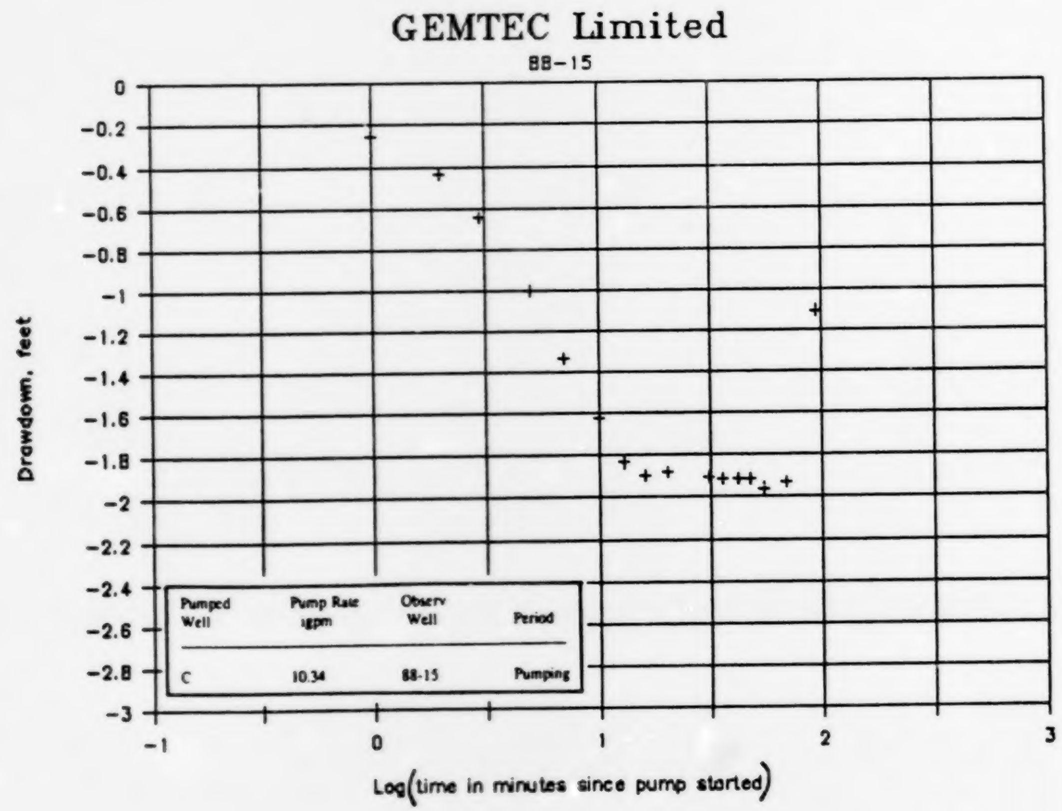


FIGURE A22

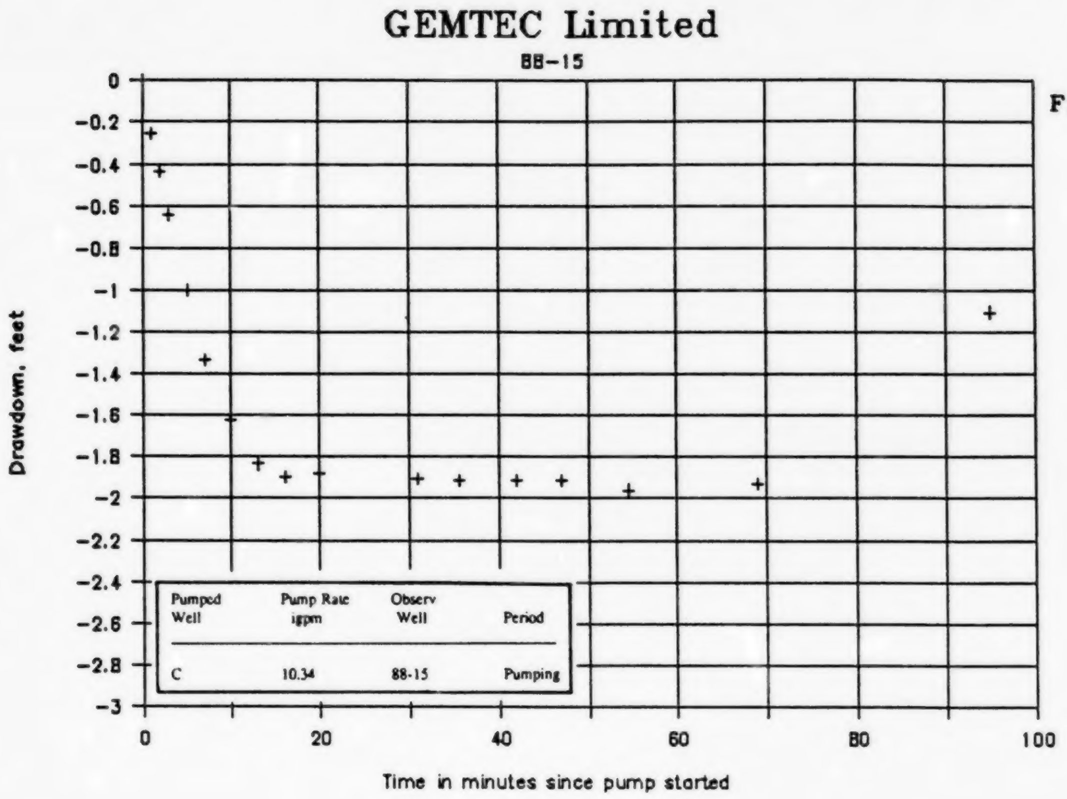


FIGURE A23

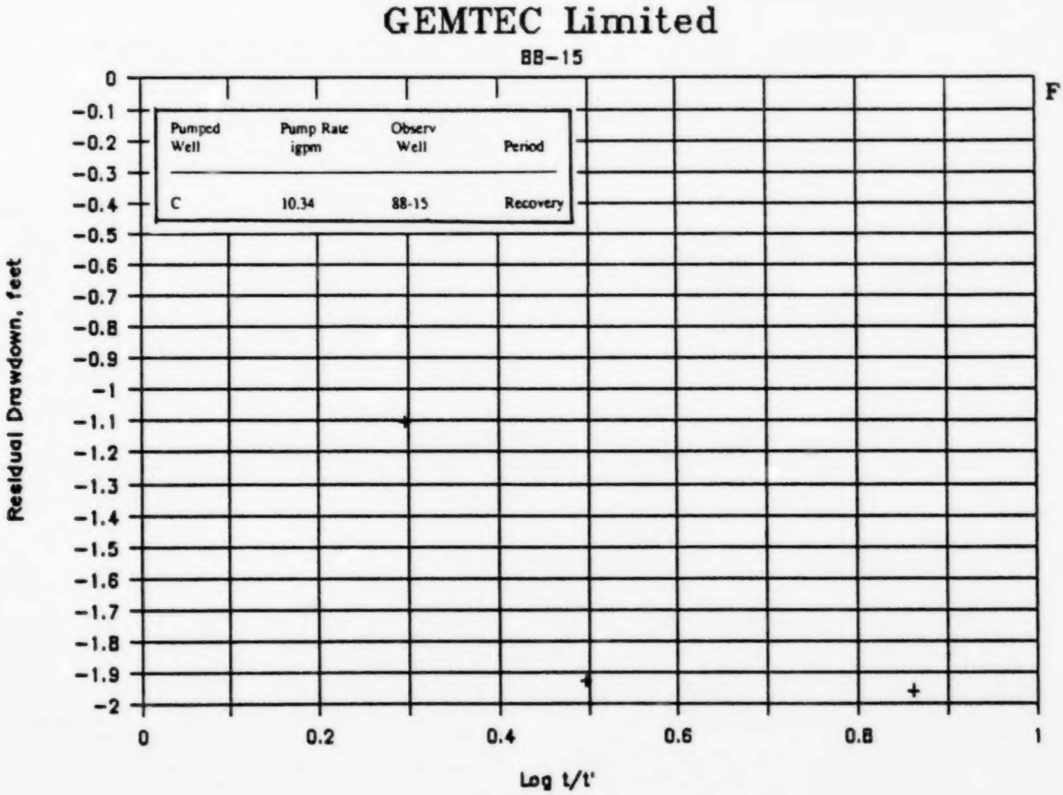


FIGURE A24

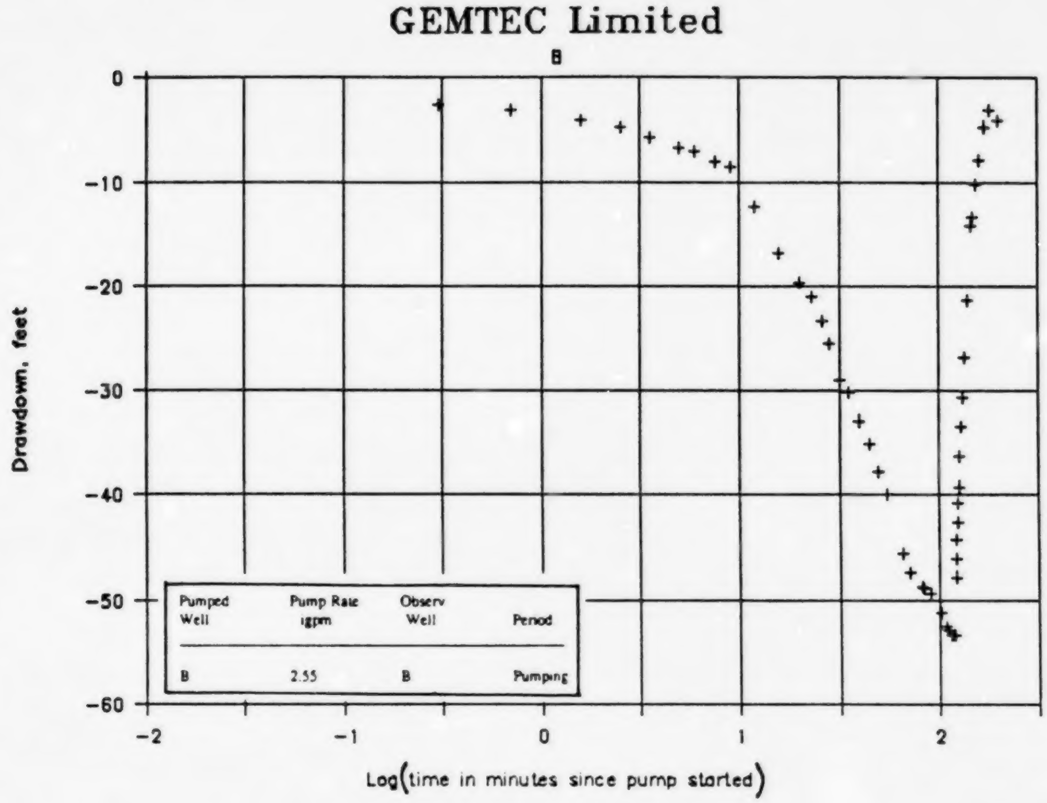


FIGURE A25

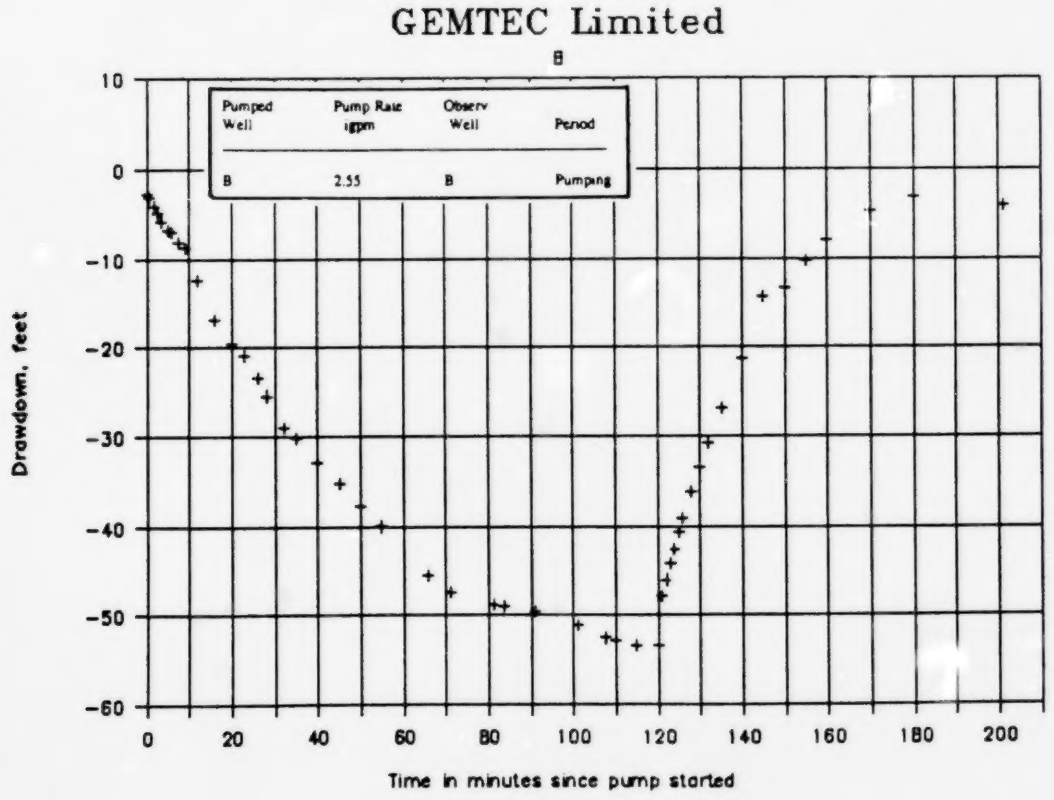


FIGURE A26

FIGURE A27

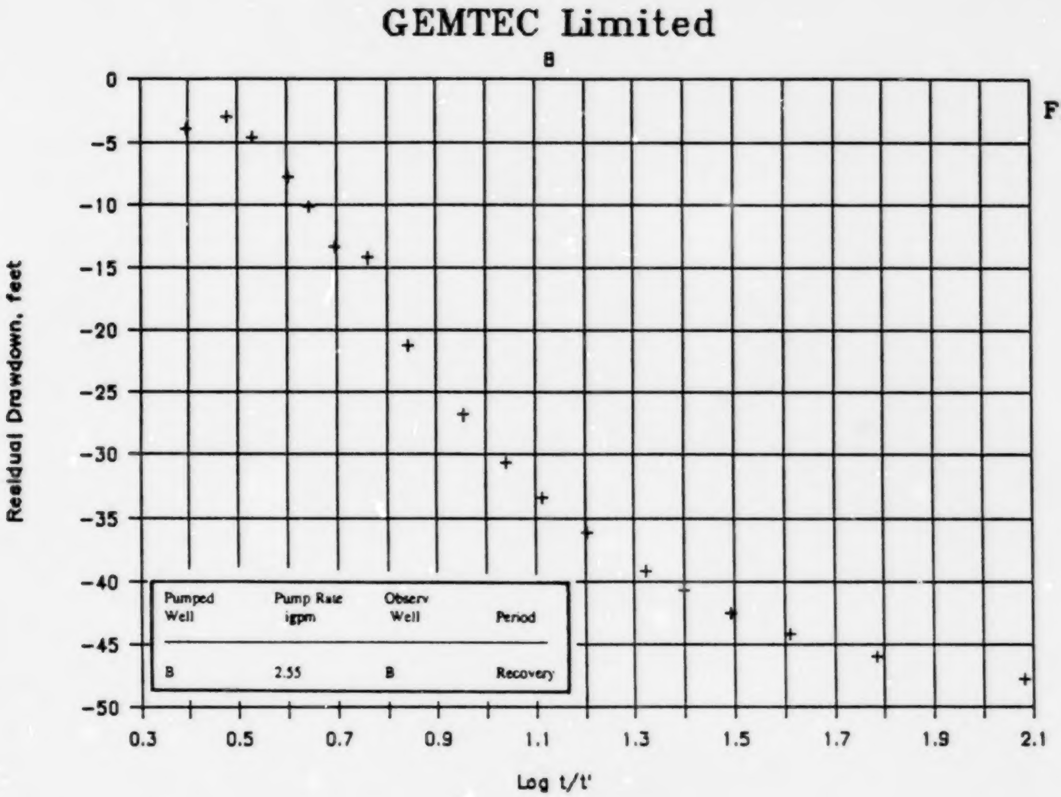


FIGURE A28

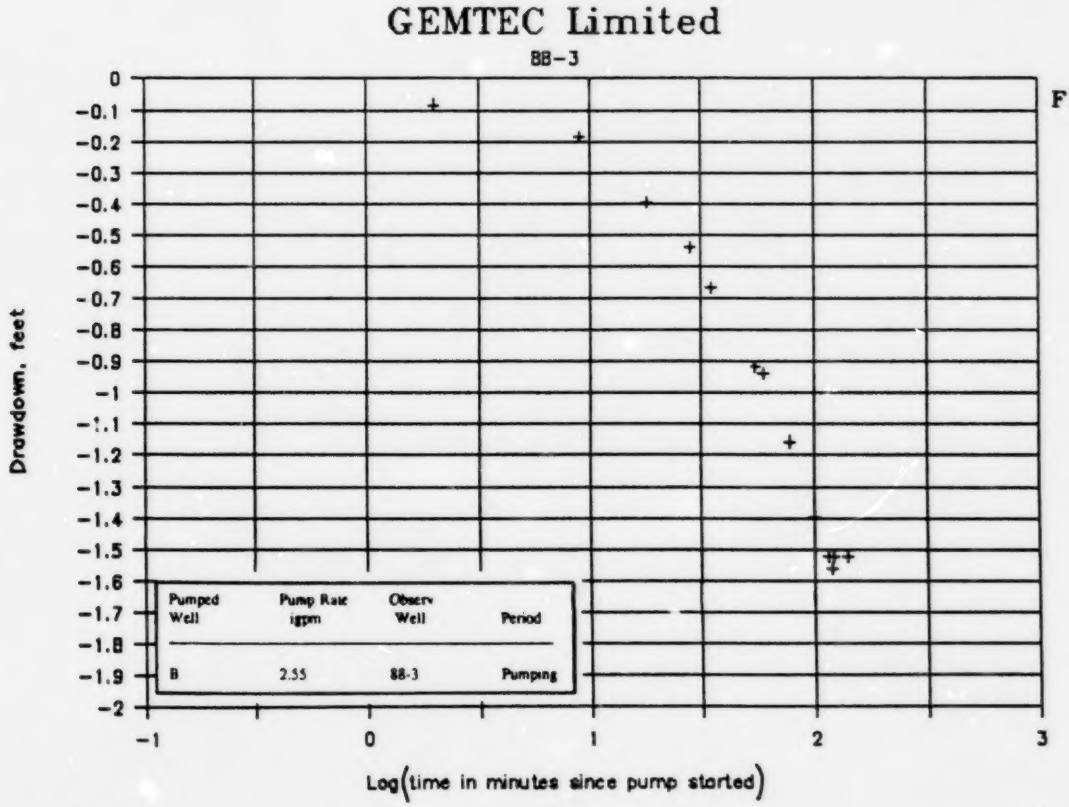
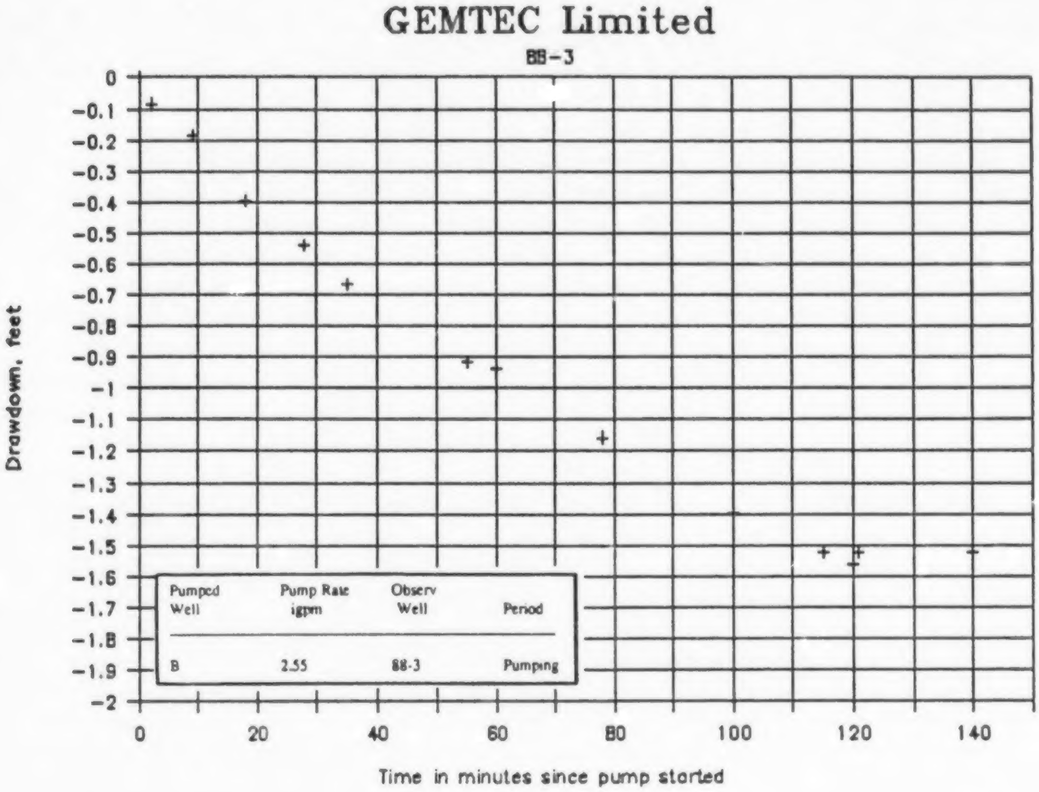


FIGURE A29


GEMTEC Limited
88-3
Drawdown, feet
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
-1.1
-1.2
-1.3
-1.4
-1.5
-1.6
-1.7
-1.8
-1.9
-2
0
20
40
60
80
100
120
140
Time in minutes since pump started
Pumped Well
Pump Rate igpm
Observ Well
Period
B
2.55
88-3
Pumping

APPENDIX H

WATER QUALITY DATA

SAMPLE LOCATIONS

Site 1 South Branch of Charlotte Brook, approximately 100 m upstream of the Restigouche site (CB-2).

Site 2 North Branch of Charlotte Brook, approximately 100 m upstream of the Restigouche site (CB-1).

Site 3 Charlotte Brook approximately 100 m downstream of Restigouche site (CB-3).

Site 4 Charlotte Brook at outlet into Upsalquitch site (CB-4).

Site 5 Southeast Upsalquitch River at outlet of Upsalquitch site (UR-5).

Site 6 Southeast Upsalquitch River at Provincial Road 180 (UR-6).

K-F LABORATORIES

P O BOX 1390
FREDERICTON N B
E3B 5E3
(506) 455-0812

• CHEMICAL ANALYSIS • MINING ASSAYS • ENVIRONMENTAL SURVEYS •

1988 09 16

PROJECT NUMBER: 1678
CLIENT: MR. KEITH PHINNEY
PROJECT DESCRIPTION: ANALYSIS OF STREAM WATER SAMPLES
SAMPLES RECEIVED: 1988 09 12
ANALYSIS COMPLETED: 1988 09 16

ANALYTICAL RESULTS: (IN MG/L)

	Site 4	Site 3	Site 2	Site 1
pH	7.54	7.48	7.65	7.46
ALKALINITY (as CaCO3)	24.1	31.2	39.2	18.6
SULFATE	4.3	3.8	3.3	3.1
Ca	7.17	9.25	12.0	5.45
Mg	2.14	2.39	2.79	1.51
Fe	0.02	0.58	0.15	< 0.02
Cu	< 0.01	< 0.01	< 0.01	< 0.01
Pb	< 0.02	< 0.02	< 0.02	< 0.02
Zn	< 0.01	0.05	0.01	< 0.01

ANALYST: ____________________
K. T. KAN, Ph.D.

K-F LABORATORIES

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• CHEMICAL ANALYSIS • MINING ASSAYS • ENVIRONMENTAL SURVEYS •

1989 07 14

PROJECT NUMBER: 1774
CLIENT: MR. KEITH PHINNEY
PROJECT DESCRIPTION: ANALYSIS OF WATER SAMPLES -- THE RESTIGOUCHE PROJECT
SAMPLES RECEIVED: 1989 07 04
ANALYSIS COMPLETED: 1989 07 14

ANALYTICAL RESULTS: (IN MG/L)

	JUNE 28-29					
	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5	SITE 6
pH	7.51	7.68	7.60	7.61	7.01	7.42
ALKALINITY (as CaCO3)	15.9	33.5	26.0	21.4	12.3	17.1
CHLORIDE	0.5	0.6	1.1	0.7	0.6	0.7
SULFATE	3.2	3.8	3.9	4.5	3.8	4.2
CALCIUM	4.80	10.3	8.05	6.65	3.93	5.94
MAGNESIUM	1.35	2.53	2.10	1.91	1.34	1.54
COLOR (T.C.U.)	< 5	< 5	< 5	< 5	10	12
TURBIDITY (N.T.U.)	0.2	0.4	0.3	0.3	0.5	1.5
ACID EXTRACTABLE METALS:						
Al	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
As	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cu	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fe	< 0.02	0.10	0.06	0.04	0.14	0.20
Mn	< 0.01	0.04	0.03	0.01	0.02	0.02
Pb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Cd			< 0.01			
Hg (ppb)			< 1			

ANALYST: K. T. K

K. T. KAN, Ph.D.

K-F LABORATORIES

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• CHEMICAL ANALYSIS • MINING ASSAYS • ENVIRONMENTAL SURVEYS •

1989 08 11

PROJECT NUMBER: 1786
CLIENT: MR. KEITH PHINNEY
PROJECT DESCRIPTION: ANALYSIS OF WATER SAMPLES -- THE RESTIGOUCHE PROJECT
SAMPLES RECEIVED: 1989 08 08
ANALYSIS COMPLETED: 1989 08 11

ANALYTICAL RESULTS: (IN MG/L)

	JULY, 1989					
	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5	SITE 6
pH	7.35	7.53	7.54	7.54	7.08	7.41
ALKALINITY (as $CaCO_3$)	17.5	34.9	27.9	23.0	13.0	20.4
CHLORIDE	0.6	0.5	1.1	1.0	0.8	0.9
SULFATE	2.8	3.2	4.1	4.3	3.8	4.2
CALCIUM	5.53	10.7	8.98	7.15	4.08	6.82
MAGNESIUM	1.47	2.56	2.27	2.05	1.37	1.69
COLOR (T.C.U.)	7	7	10	6	10	15
TURBIDITY (N.T.U.)	0.8	1.4	2.0	1.5	1.0	3.5
ACID EXTRACTABLE METALS:						
Al	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
As	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cu	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fe	0.02	0.27	0.30	0.15	0.10	0.30
Mn	< 0.01	0.14	0.10	0.05	0.03	0.02
Pb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Zn	< 0.01	< 0.01	0.02	< 0.01	< 0.01	< 0.01
Cd			< 0.01			
Hg (ppb)			< 1			
Zn (JUNE 28-29)	< 0.01	< 0.01	0.02	< 0.01	< 0.01	< 0.01

ANALYST:
K. T. KAN, Ph.D.

K-F LABORATORIES

P.O. BOX 1390
FREDERICTON, N.B.
E3B 5E3
(506) 452-1064

• CHEMICAL ANALYSIS • MINING ASSAYS • ENVIRONMENTAL SURVEYS •

1989 09 07

PROJECT NUMBER: 1800
CLIENT: MR. KEITH PHINNEY
PROJECT DESCRIPTION: ANALYSIS OF WATER SAMPLES -- THE RESTIGOUCHE PROJECT
SAMPLES RECEIVED: 1989 08 31
ANALYSIS COMPLETED: 1989 09 07

ANALYTICAL RESULTS: (IN MG/L)

	AUGUST 30					
	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5	SITE 6
pH	7.60	7.92	7.64	7.76	7.26	7.45
ALKALINITY (as CaCO3)	16.2	36.8	27.2	20.6	13.1	16.2
CHLORIDE	0.3	0.5	0.9	0.6	0.5	0.6
SULFATE	3.0	3.6	3.7	4.3	3.8	3.9
CALCIUM	5.12	11.4	8.50	6.58	4.23	5.70
MAGNESIUM	1.40	2.78	2.19	1.95	1.44	1.54
COLOR (T.C.U.)	5	5	5	< 5	15	15
TURBIDITY (N.T.U.)	0.5	0.7	0.8	0.6	1.1	2.1
ACID EXTRACTABLE METALS:						
Al	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
As	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cu	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fe	0.02	0.05	0.08	0.03	0.06	0.20
Mn	< 0.01	0.04	0.04	0.01	0.01	0.02
Pb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Zn	< 0.01	< 0.01	0.02	< 0.01	< 0.01	< 0.01
Cd			< 0.01			
Hg (ppb)			< 1			

ANALYST: K. T. Kan
K. T. KAN, Ph.D.

APPENDIX I

STREAM SEDIMENT GEOCHEMICAL DATA

STREAM SEDIMENT ANALYTICAL DATA
CHARLOTTE BROOK AREA, NB

MAP NUMBER	N.T.S.	ELEMENTS	ANALYTICAL METHOD	SIZE FRACTION	DIGESTION	LABORATORY
81-44	21 0/7E	Cu, Pb, Zn Fe, Mn	Atomic Absorption	-80 Mesh	HNO_3	N.B. Mineral Res. Branch
		Mo/Ag	Colorimetric	-80 Mesh	Fusion	N.B. Mineral Res. Branch
		U	D. Neutron Activation	-80 Mesh	HNO_3	Atomic Energy of Can. Ltd.
		As, Sb, Ba	Atomic Absorption	-80 Mesh	Acid	Chemex Laboratories Ltd.
		Au	Fire Assay	-80 Mesh		
81-46	21 0/9W	Cu, Pb, Zn Fe, Ag, Mn	Atomic Absorption	-80 Mesh	HNO_3	N.B. Mineral Res. Branch
		Mo/Ag	Colorimetric	-80 Mesh	Fusion	N.B. Mineral Res. Branch
		U	D. Neutron Activation	-80 Mesh	HNO_3	Atomic Energy of Can. Ltd.
		As, Sb, Ba	Atomic Absorption	-80 Mesh	Acid	Chemex Laboratories Ltd.
		Au	Fire Assay	-80 Mesh		
88-64	21 0/10W 21 0/9W	Cu, Pb, Zn Co, Fe, Mn Ni	Atomic Absorption	-80 Mesh	HNO_3	N.B. Mineral Res. Branch
		Mo/Ag	Colorimetric	-80 Mesh	Fusion	N.B. Mineral Res. Branch
		U	D. Neutron Activation	-80 Mesh	HNO_3	Atomic Energy of Can. Ltd.
		As, Sb, Ba	Atomic Absorption	-80 Mesh	Acid	Chemex Laboratories Ltd.
		Au	Fire Assay	-80 Mesh		
81-45	21 0/8W	Cu, Pb, Zn Fe, Mn	Atomic Absorption	-80 Mesh	HNO_3	N.B. Mineral Res. Branch
		Mo/Ag	Colorimetric	-80 Mesh	Fusion	N.B. Mineral Res. Branch
		U	D. Neutron Activation	-80 Mesh	HNO_3	Atomic Energy of Can. Ltd.

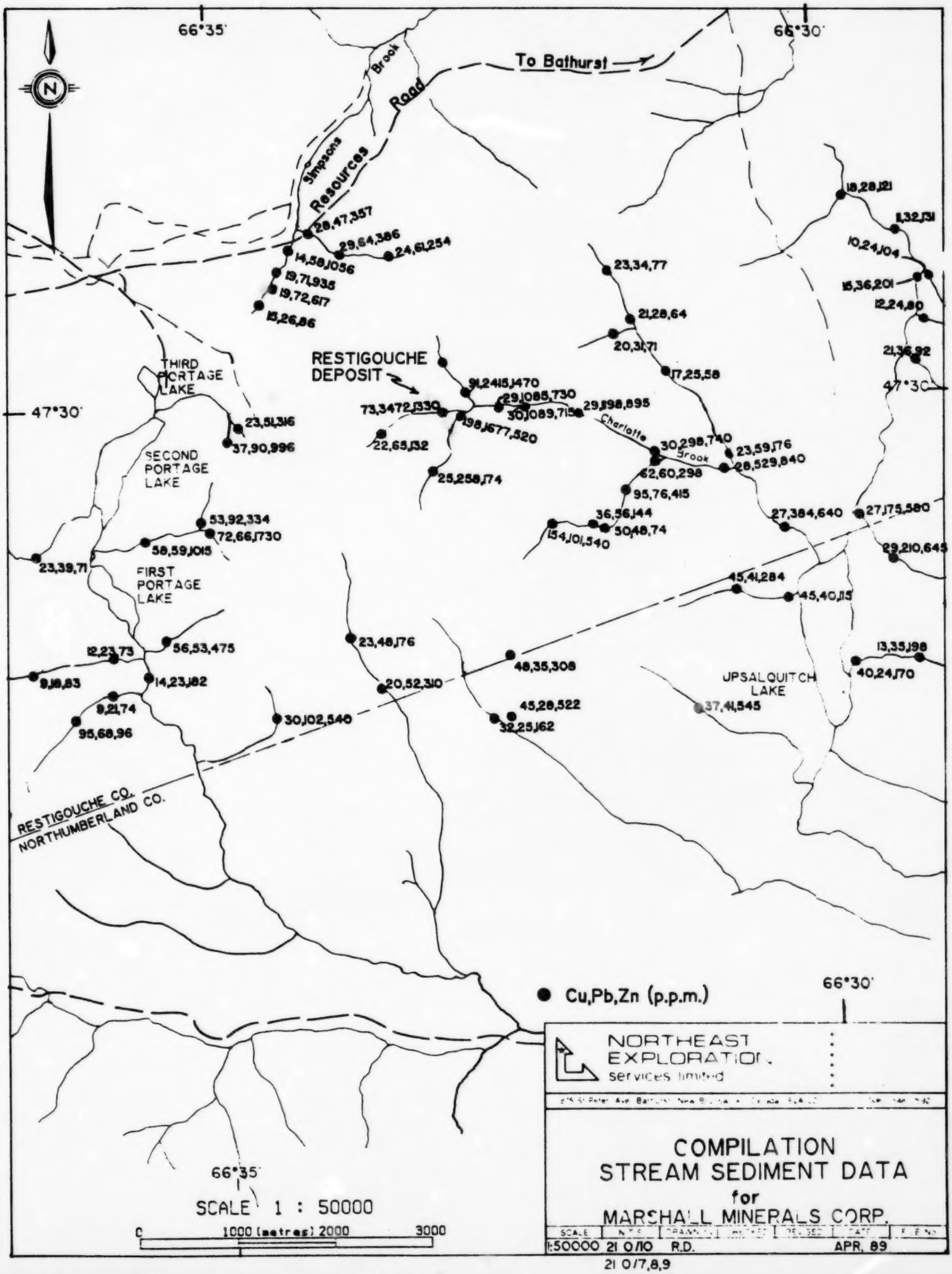
LIST OF FIGURES

COMPILATION STREAM SEDIMENT DATA Cu, Pb Zn (ppm)

COMPILATION STREAM SEDIMENT DATA Fe, Mn (ppm)

COMPILATION STREAM SEDIMENT DATA Mo, Ag, U (ppm)

COMPILATION STREAM SEDIMENT DATA As, Sb, Ba (ppm)


66°35'
66°30'
N
To Bathurst
Brook
Road
Simpsons
Resources
28,47,357
29,64,386
24,61,254
14,58,1056
19,71,935
19,72,617
15,26,86
18,28,121
1,32,131
10,24,104
16,36,201
12,24,80
21,36,92
47°30'
23,34,77
21,28,64
20,31,71
17,25,58
THIRD PORTAGE LAKE
RESTIGOUCHE DEPOSIT
91,2415,1470
29,1085,730
30,1089,715
29,198,895
73,3472,1330
198,1677,520
22,65,132
25,258,174
47°30'
23,51,316
37,90,996
SECOND PORTAGE LAKE
Charlotte Brook
30,298,740
23,59,176
28,529,840
62,60,298
95,76,415
36,56,144
30,48,74
154,101,540
27,384,640
27,175,580
29,210,645
53,92,334
72,66,1730
58,59,1015
23,39,71
FIRST PORTAGE LAKE
45,41,284
45,40,115
12,23,73
56,53,475
9,18,83
14,23,182
9,21,74
95,68,96
23,48,176
20,52,310
30,102,540
48,35,308
45,28,522
32,25,162
UPSALQUITCH LAKE
37,41,545
13,35,198
40,24,170
RESTIGOUCHE CO.
NORTHUMBERLAND CO.
● Cu,Pb,Zn (p.p.m.)
66°30'
66°35'
SCALE 1 : 50000
0
1000 (metres) 2000
3000

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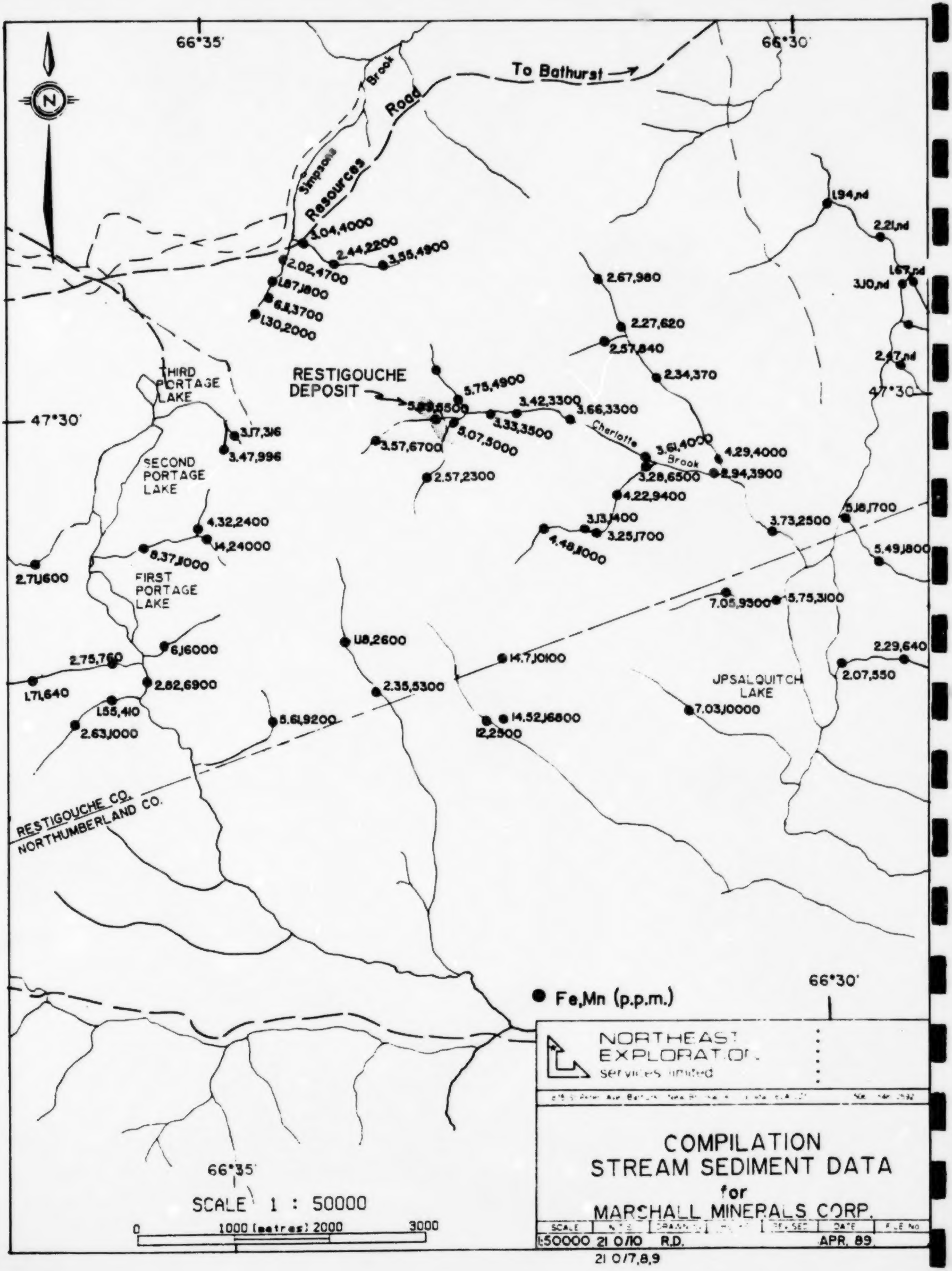
COMPILATION
STREAM SEDIMENT DATA
for
MARSHALL MINERALS CORP.

SCALE	N.T.S.	DRAWN BY	CHECKED	REVISED	DATE	FILE NO.
1:50000	21 O/10	R.D.			APR. 89	

21 O/7,8,9


66°35'
66°30'
N
To Bathurst
Brook
Road
Simpsons
Resources
3.04,4000
2.44,2200
3.55,4900
2.02,4700
1.87,1800
6.11,3700
1.30,2000
1.94,nd
2.21,nd
1.67,nd
3.10,nd
2.47,nd
47°30'
2.67,980
2.27,620
2.57,840
2.34,370
THIRD PORTAGE LAKE
RESTIGOUCHE DEPOSIT
5.75,4900
5.89,5500
3.42,3300
3.66,3300
3.33,3500
5.07,5000
3.57,6700
Charlotte
Brook
3.61,4000
4.29,4000
3.28,6500
2.94,3900
2.57,2300
47°30'
3.17,316
3.47,996
SECOND PORTAGE LAKE
4.22,9400
3.13,1400
3.25,1700
4.48,1000
3.73,2500
5.18,1700
5.49,1800
4.32,2400
14,24000
8.37,1000
2.71,1600
FIRST PORTAGE LAKE
7.05,9300
5.75,3100
1.18,2600
6.1,6000
2.75,760
14.7,10100
2.29,640
2.07,550
1.71,640
2.82,6900
2.35,5300
UPSALQUITCH LAKE
1.55,410
7.03,10000
5.61,9200
14.52,16800
12,2500
2.63,1000
RESTIGOUCHE CO.
NORTHUMBERLAND CO.
● Fe,Mn (p.p.m.)
66°30'
66°35'
SCALE 1 : 50000
0
1000 (metres) 2000
3000

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[illegible]

COMPILATION
STREAM SEDIMENT DATA
for
MARSHALL MINERALS CORP.

SCALE	N.T.S.	DRAWN	[illegible]	REVISED	DATE	FILE No
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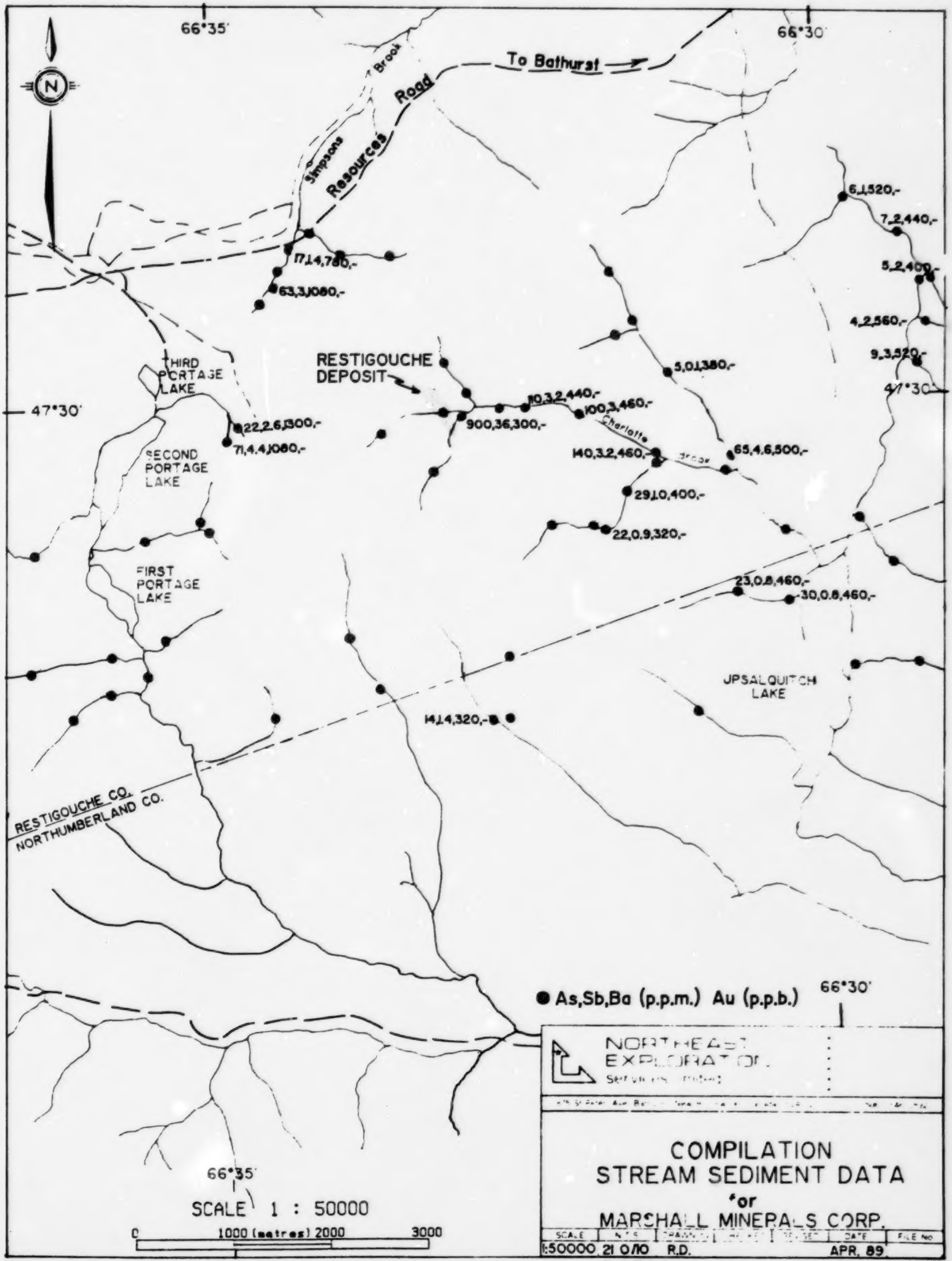
66°35'
66°30'
N
To Bathurst
Resources Road
Simpsons Brook
17,1.4,780,-
63,3,1080,-
THIRD PORTAGE LAKE
RESTIGOUCHE DEPOSIT
47°30'
22,2.6,1300,-
71,4.4,1080,-
SECOND PORTAGE LAKE
FIRST PORTAGE LAKE
10,3.2,440,-
100,3,460,-
900,36,300,-
Charlotte Brook
5,0.1,380,-
140,3.2,460,-
65,4.6,500,-
29,1.0,400,-
22,0.9,320,-
6,1,520,-
7,2,440,-
5,2,400,-
4,2,560,-
9,3,520,-
47°30'
23,0.8,460,-
30,0.8,460,-
UPSALQUITCH LAKE
14,1.4,320,-
RESTIGOUCHE CO.
NORTHUMBERLAND CO.
● As,Sb,Ba (p.p.m.) Au (p.p.b.)
66°30'
66°35'
SCALE 1 : 50000
0
1000 (metres) 2000
3000

NORTHEAST
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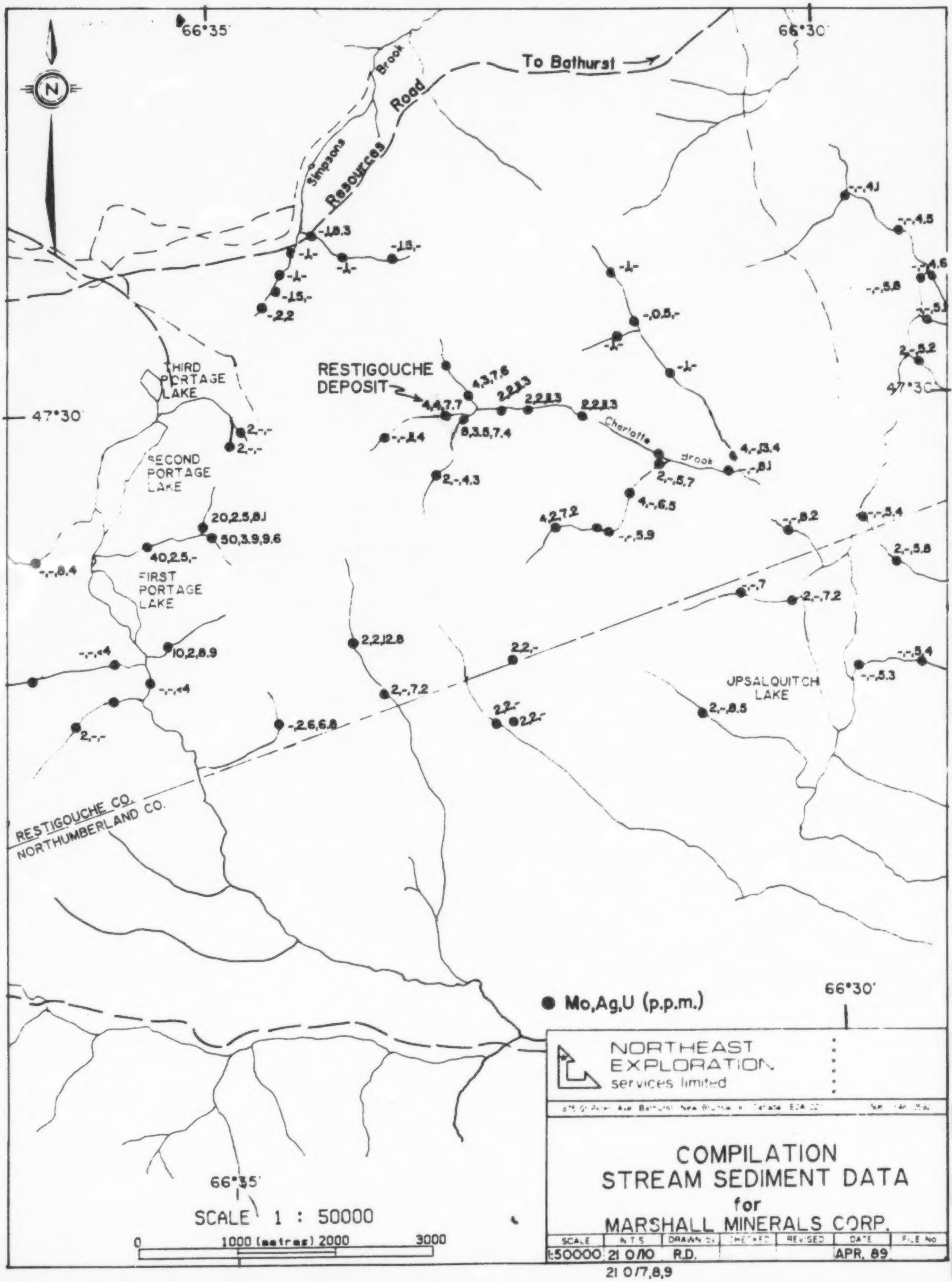
COMPILATION
STREAM SEDIMENT DATA
for
MARSHALL MINERALS CORP.

SCALE	N.T.S.	DRAWN	CHECKED	REVISED	DATE	FILE No
1:50000	21 O/10 21 O/7,8,9	R.D.			APR. 89	


66°35'
66°30'
N
To Bathurst
Brook
Road
Simpsons
Resources
-,1.8,3
-,1,-
-,1,-
-,1.3,-
-,1,-
-,1.5,-
-,2.2
-,1,-
-,0.5,-
-,1,-
-,1,-
-,-,4.1
-,-,4.5
-,-,4.6
-,-,5.8
-,-,5.1
2,-,5.2
47°30'
47°30'
THIRD PORTAGE LAKE
RESTIGOUCHE DEPOSIT
4,3,7.6
2,2,1.3
2,2,1.3
2,2,1.3
4,4,7.7
8,3,5,7.4
-,-,1.4
2,-,-
2,-,-
SECOND PORTAGE LAKE
2,-,4.3
Charlotte Brook
4,-,13.4
-,-,8.1
2,-,5.7
4,-,6.5
4,2,7.2
-,-,5.9
20,2.5,8.1
50,3.9,9.6
40,2.5,-
-,-,8.4
FIRST PORTAGE LAKE
-,-,8.2
-,-,5.4
2,-,5.8
-,-,7
2,-,7.2
2,2,12.8
10,2,8.9
-,-,<4
-,-,<4
2,-,-
-,2.6,6.8
2,-,7.2
2,2,-
2,2,-
2,2,-
UPSALQUITCH LAKE
2,-,8.5
-,-,5.4
-,-,5.3
RESTIGOUCHE CO.
NORTHUMBERLAND CO.
66°30'
66°35'
SCALE 1 : 50000
0
1000 (metres) 2000
3000

● Mo,Ag,U (p.p.m.)

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COMPILATION
STREAM SEDIMENT DATA
for
MARSHALL MINERALS CORP.

SCALE	N.T.S.	DRAWN BY	CHECKED	REVISED	DATE	FILE NO
1:50000	21 O/10 21 O/7,8,9	R.D.			APR. 89	

REPORT NUMBER: PCAS/89/181 DATE: August 25, 1989

JOB NUMBER: 04000390/0568

PCAS CODES:

TO:
K. D. Phinney
Consulting Chemist/Engineer
52 Shore Street
Fredericton, N. B.
E3B 1R2

Analytical Report - Geochemistry
(Dry weight basis)

Lab Code	Sample	ppm As	ppm Cu	% Fe	ppm Mn	ppm Pb	ppm Zn	% L.O.I.
568-1	Site 1	232	109.5	1.68	1936	450.7	148.5	16.63
	-80 mesh							
568-2	Site 2	412	104.8	4.74	1017	158.8	139.8	39.74
	-80 mesh							
568-3	Site 3	677	133.8	5.54	6283	2393	1218	22.33
	-80 mesh							
568-4	Site 4	270	49.8	2.34	1008	295.8	445.5	21.82
	-80 mesh							
568-5	Site 5	199	175.8	1.93	1738	490.5	213.3	14.70
	-80 mesh							
568-6	Site 6	262	37.8	2.20	1205	99.3	133.5	8.70
	-80 mesh							

I. J. J. Delaney

Signed

APPENDIX J

HABITAT DESCRIPTION

HABITAT DESCRIPTION

SAMPLE SITE	DESCRIPTION
CB-1 (south branch)	- 1 m wide, 10 cm deep - gradient approx. 5 or 6% - gravel, rubble, boulder substrate - completely shaded; closed forest canopy - majority of rock covered by aquatic moss
CB-2a (north branch)	- 1.5 m wide, 10 - 15 cm deep - slow flow between beaver ponds - gravel, boulder overlain by organic sediment - closed canopy; balsam fir and alder cover
CB-2b (200 m upstream of CB-2a)	- 1 - 1.5 m wide, 5 - 15 cm deep - steep gradient, free flowing water - sand, gravel, rubble, boulder substrate - completely canopy shaded
CB-3 (downstream of mine site)	- 2.5 m wide, 15 cm deep - slow - moderate flow rate - coarse, gravel, rubble with interlain sand and fine gravel - completely shaded
CB-4 (near Upsalquitch Lake)	- 4.5 m wide, 15 cm deep - moderate flow, riffle habitat - rubble, boulder with pockets of sand and gravel - mostly open with fallen logs and boulders for cover
UR-5 (Southeast Upsalquitch River near lake)	- 8.5 m wide, 15 - 20 cm deep - slow-moderate flow, riffle habitat - rubble with a few boulders and gravel - alder cover only
UR-6 (Southeast Upsalquitch River at Route 180)	- 15 m wide, 40 cm deep - slow flow - gravel, rubble with mud along the banks - alder cover only